University of Poonch Rawalakot
Azad Jammu& Kashmir
Department of Physics

AGENDA

Seventh Meeting of Departmental Council

October 2023

Department of Physics
University of The Poonch Rawalakot
Azad Jammu and Kashmir

INTRODUCTION

The Department of Physics was established in March 2013 in the City Campus of the University of Poonch Rawalakot (UPR) Azad Jammu and Kashmir. The Department currently offers BS 4-years, MS/MPhil and PhD Physics programs successfully.

The department is committed to ensuring quality teaching and research in the different areas of Physics, which meet all the educational standards of the Higher Education Commission. It is the mission of the department to produce professionally skilled and academically sound Physicists to be helpful in resolving the challenges which are useful directly or indirectly to improve the quality of human life and the economy of the country. The department is always devoted to enhancing student's professional skills and career opportunities. Different study tours and visits are regularly being arranged to expose the students and faculty to various national and international conferences/seminars on current issues relating to the other fields of Physics. Faculty members also actively participate and present their research works at various national and international conferences/symposia regularly.

To ensure the quality of teaching and research, the qualified faculty has been inducted purely on merit. Furthermore, the department is fully cooperating with the Quality Enhancement Cell (QEC) of the University to incorporate their recommendations for improving the standard of teaching, quality of learning, and achievement of its objectives. To maintain and enhance the required standard and quality of higher education, the department revises and updates the syllabi of courses at different degree programs. This document contains the agenda of the 7th Board of Studies (BOS) meeting with updated syllabi for PhD, MS/MPhil, and BS (4 years) degree programs offered in the Department of Physics. All these syllabi are updated to fulfill the required standard of the Higher Education Commission.

Scheme of Studies for Graduate Degrees in Physics
(PhD and MS/MPhil in Physics)

PhD Program

Program Title:	Doctor of Philosophy in Physics
Duration	**3-8 Years**
Course Work	**18 Credit Hours**
Research Thesis (PHY-799)	**24 Credit Hours**
Seminar/Presentation (PHY-797)	**01 Credit Hours**
Total Credit Hours	**43**
Comprehensive Examination in written (PHY-796) P/F	

Objectives of PhD Program:

The program mentioned above aims to train researchers to start and complete satisfactory original, innovative, and quality research that culminates in the public presentation of the Ph.D. thesis.

Eligibility: As per HEC Criteria

Semester Wise Scheme for PhD in Physics

Semester-I				
S. No.	Course Code	Name of Subject	Credit Hours	Remarks
1		Graduate Level Physics Course	3(3-0)	Elective-I
2		Graduate Level Physics Course	3(3-0)	Elective-II
3		Graduate Level Physics Course	3(3-0)	Elective-III
Total			**09**	
Semester-II				
4		Graduate Level Physics Course	3(3-0)	Elective-IV
5		Graduate Level Physics Course	3(3-0)	Elective-V
6		Graduate Level Physics Course	3(3-0)	Elective-VI
Total Credit Hours			**09**	

Note: Elective courses are offered according to the availability of faculty.
P= Pass (Minimum 60 % marks in written), F=Fail

MS/MPhil Program

Program Title: Master of Science in Physics (MS) / Master of Philosophy in Physics (MPhil)

Duration	**1.5 -4 Years**
Course Work (taught based)*	**30 Credit Hours**
Course Work (Research-based)	**24 Credit Hours**
Dissertation/Thesis (only for Research-based) (PHY-790)	**06 Credit Hours**
Seminar/Presentation (PHY-795)	**01 Credit Hours**
Total Credit Hours	**31**

Objectives of the Program:

The Department of Physics offers the MS/MPhil as a full-time research period and introduces students to research skills and specialist knowledge. Its main aims are:

- To give students with relevant experience, at the first-degree level, the opportunity to carry out focused research in the discipline under close supervision.
- To give students the opportunity to acquire or develop skills and expertise relevant to their research interests.

By the end of the program, students will have:

- A comprehensive understanding of techniques and a thorough knowledge of the literature applicable to their own research.
- Demonstrated originality in applying knowledge, together with a practical understanding of how research and inquiry are used to create and interpret knowledge in their field.
- Showed abilities in critically evaluating current research and research techniques and methodologies.
- Demonstrated some self-direction and originality in tackling and solving problems, acted autonomously in the planning, and implementing research.
- Produced a dissertation for examination.

Eligibility:

- MSc /BS (4 years) in physics from any HEC recognized University with at least 2nd division with 45% aggregate in annual system /2.5 CGPA in semester system.
- No third division in academic career.
- Valid Entrance test (UGAT) result with at least 50% marks.
- Overall merit comprises academic record and entrance test result.

*The scholars with taught-based MPhil are not eligible for higher degrees in relevant fields unless and until they complete 6 credit hours of research work.

Semester wise Scheme for MS/MPhil in Physics

Semester-I				
S.No.	Course Code	Name of the Subject	Credit Hours	Remarks
1	PHY-701	Quantum Physics	3(3-0)	Compulsory
2	PHY-702	Statistical Physics	3(3-0)	Compulsory
3		Graduate Level Physics Course	3(3-0)	Elective-I
4		Graduate Level Physics Course	3(3-0)	Elective-II
Total Credit Hours			**12**	
Semester-II				
5	PHY-703	Electrodynamics	3(3-0)	Compulsory
6	PHY-704	Mathematical Methods of Physics	3(3-0)	Compulsory
7		Graduate Level Physics Course	3(3-0)	Elective-III
8		Graduate Level Physics Course	3(3-0)	Elective-IV
Total Credit Hours			**12**	

Note:

Elective courses are swapped according to the availability of faculty. Six (06) credit hours of research work will be conducted during the 3rd and 4th semesters for the research-oriented MPhil program only, and the student of the taught-oriented MPhil program will complete six credit hours more course work in 3rd and 4th semesters. Seminar/presentation (PHY-795) will be held at the time of submission of their research plan/synopsis before the supervisory committee.

ELECTIVE COURSES FOR GRADUATE STUDIES (MS/MPhil and PhD in PHYSICS)

S. No	Course Code	Course Title	C .Hours
1	PHY-705	Materials Science-I	3(3-0)
4	PHY-706	Atomic and Molecular Physics	3(3-0)
5	PHY-707	Condensed Matter Theory-I	3(3-0)
6	PHY-708	Introduction to Nanophysics and Applications	3(3-0)
8	PHY-709	Physics of Thin Films	3(3-0)
9	PHY-710	Semiconductor Devices	3(3-0)
10	PHY-711	Modern Optics and Laser Physics	3(3-0)
11	PHY-712	Particle Physics	3(3-0)
12	PHY-713	Advance Quantum Mechanics	3(3-0)
13	PHY-714	Quantum Information Theory	3(3-0)
14	PHY-715	Quantum Optics	3(3-0)
18	PHY-716	Superconductivity	3(3-0)
20	PHY-717	Medical Physics	3(3-0)
21	PHY-718	Material Preparation and Characterization Techniques	3(3-0)
22	PHY-719	Condensed Matter Theory-II	3(3-0)
23	PHY-720	Introduction to Polymers, Ceramics and Composites	3(3-0)
24	PHY-721	Theory of Dielectric Materials	3(3-0)
25	PHY-722	Biomass Technologies	3(3-0)
26	PHY-723	Advanced Solid State Physics-I	3(3-0)
27	PHY-724	Advanced Solid State Physics-II	3(3-0)
28	PHY-725	Imaging and characterization techniques for Nanostructures	3(3-0)
29	PHY-726	Theory of Magnetic Materials	3(3-0)
30	PHY-727	Nanophotonics and Metamaterials	3(3-0)
31	PHY-728	Luminescence of Solid Materials	3(3-0)
32	PHY-729	Functional Materials and Devices	3(3-0)
33	PHY-730	Atomistic Simulations of Materials	3(3-0)
34	PHY-731	Renewable Energy Sources	3(3-0)
35	PHY-732	Materials Science-II	3(3-0)
36	PHY-733	Plasma Spectroscopy and Applications	3(3-0)
36	PHY-734	Advanced Laser Physics	3(3-0)
37	PHY-735	Two-dimensional Materials and Applications	3(3-0)
Research Work			
26	PHY-790	MPhil Research Dissertation	6
27	PHY-799	PhD Research Thesis	30

Course Contents MS/MPhil/PhD

PHY-701: Quantum Physics Credit Hours: 3(3-0)

Fundamental of Quantum Concepts:

Introduction to fundamental idea of Quantum Mechanics.

Electromagnetic waves and photons; Light quanta and the Plank-Einstein relations, wave particle duality, Analysis 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, Quantum description of a particle Wave packets; Heisenberg uncertainty relation, Derivation of uncertainty principle from de Broglie's concept, Heisenberg's Gamma ray Microscope.

Wave Mechanics:

Introduction, Double slit experiment in Wave Mechanics, Wave function and its physical significance, Schrodinger's equation (time dependent and time independent), Applications of Schrodinger's equation, Solution of Schrodinger's Equation for spherically symmetric problems, Schrodinger equation for H-atom, Legendre polynomials, associated Legendre Functions, qualitative discussion of spherical Harmonics.

Operator Formulism:

Linear operator, The commutator, Eigen function and Eigen values, simultaneous Eigen functions, Observations and Expectation values, Postulates, The Ehrenfest Theorem, Energy Eigen Function, Hermitaion Operators and properties, Completeness of Eigen Function, Operator for conserved quantities, The unitary operator, The parity operator.

Dirac Representation Theory:

An n-dimensional vector Space, the state vector in Dirac representation and Hilbert space, properties and physical significance of Hilbert space, Dirac Representation of Operators, Relation between Dirac's ket and Bra and matrices.

Linear Harmonic Oscillator:

Solution of Schrodinger's equation using Ladder operators and their matrices, Energy Eigen States, matrices for Momentum, Position and Hamiltonian operators, Expectation values of various operators, The Coherent states, Time evolution of Coherent State, The Quantum Mechanical Pictures(Schrodinger, Heisenberg and Interaction pictures).

Angular Momentum:

Angular Momentum operator, Orbital angular Momentum, Commutation relations, Orbital angular momentum in spherical polar coordinates, Eigen functions and Eigen values of L^2 and L_z matrices for L2 L_x,L_y, L_z Ladder operators for L, Spherical Harmonics of angular momentum, Spin angular momentum, Commutation relations, Pauli spin Matrices and properties, representation for spin angular momentum wave function, vector representation of spin angular momentum, Eigen values and Eigen functions for components of S operator, magnetic moments of an electron, The Stern-Gerlach Experiment, Addition of Angular momenta, L-S Coupling, J-J Coupling, Spectroscopic Notations, The matrix representation of J2, Jz, Jx, Jy and $J\pm$ Clebsch-Gordan coefficients.

Perturbation Theory:

Introduction, Time independent perturbation theory, Non-degenerate case, Evaluation of First order energy, first order wave function, second order energy, second order wave function, Degenerate case only doubly degenerate, Physical Applications of Time independent perturbation theory(Normal He-Atom, Zeeman effect without spin), Time dependent perturbation theory, first order perturbation, transition into continuous spectrum(Golden Rule), Harmonic Perturbation, Adiabatic Perturbation, Applications of Time dependent perturbation theory.

Recommended Textbook:

1. Quantum Mechanics (Vol. 1) by Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe, Wiley-VCH, 1992.
2. Modern Quantum Mechanics (2nd Edition) byJ. J. Sakurai, Jim J. Napolitano, Addison-Wesley, 2010.
3. Principles of Quantum Mechanics (2nd Edition) by R. Shankar, Plenum Press, 1994.
4. Textbook Of Quantum Mechanics (2^{nd} Ed) by AK Saxena CBS Publisher & Distributors 2012.

PHY-702: Statistical Physics Credit Hours: 3(3-0)

Review of Thermodynamics:

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:

Collision less 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 and 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 Mechanics, John Dirk Walecka, College of William and Mary, USA, 2011
2. Statistical Physics, James P Sethna, Oxford University Press, 2006
3. Introduction to Statistical Physics, Kerson Huang, (Taylor and Francis, 2001).
4. Statistical Mechanics, Raj Kumar Pathria, 2nd edition (India, 1996).

PHY-703: Electrodynamics 3(3-0) Credit Hours

Introduction to Electrostatics:

Introduction to electrostatics, Coulombs law, electric field, gauss's law, surface distribution of charges and dipoles, Poison and Laplace equations, electrostatic potential energy and energy density, boundary conditions and relations of microscopic to macroscopic fields, the displacement vector, the electric field in a material medium, polarizability, solution of potential problems, uniqueness theorem, solution by green functions solutions by inversion, solution by electrical images, two dimensional potential problems and application, three dimensional potential problems and applications, energy relations and force in the electrostatic field, field energy in free space, energy density in a dielectric, volume forces in the electrostatic field in the presence of dielectrics, .

Electrostatics II:

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.

Magnetostatics:

Steady currents and their interactions, the magnetic interaction of steady line currents, the magnetic scalar and vector potentials.

Magnetic materials and boundary value problems, magnetic field intensity, magnetic sources, magnetic susceptibility uniqueness theorem for the vector potential,

Electrodynamics:

Maxwell's equations for stationary and moving media, energy relations in quasi-stationary current systems, forces on current systems magnetic volume force, the wave equation and plane waves, radiation pressure, plane waves in a moving medium, waves in conducting media, group velocity, the wave equation for the potentials, the radiation field, radiated energy, the Hertz potential, electric dipole radiation, multiple radiation, radiation from an accelerated charge, field of an accelerated charge, radiation at low velocity, transformation properties of free radiation field, electromagnetic mass, radioactive damping of the charged harmonic oscillator, forced vibrations scattering by an individual free electron, scattering by a bound electron, absorption of radiation by an oscillator, scattering from a volume distribution, the dispersion relation, the motion of charged particles in the electromagnetic fields, world line description, Hamiltonian formulation and transition to three dimensional formalism, equation for the trajectories of the motion of a particle with magnetic moment in an electromagnet field.

Recommended Books:

1. Classical Electrodynamics by J. D. Jackson (3rd Edition), Wiley 1998.
2. Classical Electricity and Magnetism, Wolfgang K. H. Panofsky and Melba Philips, Addison Wesley Publishing Co. 1990.
3. Electrodynamics: An Intensive Course, Masud Chaichian, Ioan Merches, Daniel Radu, Anca Tureanu, Springer Science & Business Media, 2016.
4. Fields and Waves and Waves Electromagnetic, David K. Cheng, Addison Wesley 1989.
5. Elements of Electrodynamics, Matthew N. O., Sadiku Sunders, Chicago 1993.
6. Electromagnetic Field Theory, Zahn M. Willey, New York, 1979.

PHY-704: Mathematical Methods of Physics Credit Hours: 3(3-0)

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, and 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).
3. Mathematical Methods in Physics, Philippe Blanchard Erwin Brüning, Springer Science+Business Media, 2003.

PHY-705: Materials Science-I Credit Hours: 3(3-0)

Interatomic Bonding in Materials:

Bonding in Elemental Materials (Covalent, Metallic and vander Waals Bonding), Bonding in Multi-element 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 Networking 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 Interfaces, Stacking Period and Interplanar Spacing, Defects on Surfaces, Experimental Determination and Creation of Surfaces, Surface Characterization Techniques (LEED, MBE, STM and AFM) and Their Principles.

Soft Condensed Matter:

Introduction to Soft, 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.

Recommended Books:

1. Materials Science and Engineering, An Introduction, W.D. Callister, Jr., publisher John Wiley & Sons Inc (2007).
2. The Physics and Chemistry of Materials, J. I. Gersten and F.W. Smith, publisher John Wiley & Sons Inc (2001).
3. Fundamentals of Ceramics, 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, M. Ohring, (2^{nd} edition) Publishers Academic Press (2002).
7. Soft Condensed Matter, R.A. L. Jones, Publishers Oxford University Press(2002).

PHY-706: Atomic and Molecular Physics Credit Hours: 3(3-0)

One-electron atoms:

Energy levels and wavefunctions 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 atomsAutoionization. Fano's description for an isolated autoionizing 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). Nonhydrogenic 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, C.J. Foot, 1st Edition (Oxford University Press) 2005.
2. Atomic and Molecular Spectroscopy, S. Svanberg. 4th Ed. (Springer) 2004.
3. Spectra of Atoms and Molecules, P.F. Bernath, 2nd Ed. (Oxford), 2005.
4. Physics of Atoms and Molecules, Bransden and Joachain, (Longman), 1985.
5. Atomic Spectroscopy, Heckmann and Trabert (Springer), 1995.
6. Laser Spectroscopy, W. Demtroeder (Springer), 2004.
7. The Fundamentals of Atomic and Molecular Physics, Brooks, Robert L Springer-Verlag New York, 2013.

PHY-707: Condensed Matter Theory-I Credit Hours: 3(3-0)

Introduction:

Overview of modern condensed matter physics more is different, emergent properties. Broken symmetry, quasiparticles and collective phenomena: Symmetry, importance of broken symmetry, adiabatic continuity 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, and 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, P. Philips, publisher: Westview Press; 1st edition, (2003).
2. Condensed Matter Field Theory, A. Altland and B. Simons, publisher: Cambridge University Press, 1st edition (2006).
3. Advanced Condensed Matter Physics, L. M. Sander, publisher: Cambridge University Press, 1st edition (2009).

PHY-708: Introduction to Nanophysics and Applications Credit Hours: 3(3-0)

Introduction:

Nanophysics and nanotechnology, scaling laws and limits to smallness, quantum nature of nano-world, Synthesis of nanomaterials, Mechanical grinding, Gas phase synthesis, Sputtering, Laser ablation.

Properties of nanomaterials:

Electronic, Magnetic, optical and mechanical. Applications of semiconductor nanostructures, fabrication of semiconductor nanowires and quantum dots, electronic and optical properties, optical spectroscopy of semiconductor nanostructures, carbon nanostructures, nanomagnets.

Applications of nanomaterials:

Environmental applications, Biological applications. Nanostructured gas sensors, Environmental sensors and monitoring, Soil remediation, Water treatment, Air purification.

Recommended Books:

1. Introduction to Nanotechnology, Charles Poole Jr., F. J. Owens, John Wiley & Sons, Inc., 2003.

2. Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, Wiley-VCH 2006.
3. Nanostructuresand nanomaterials, synthesis, properties and applications, Cao, Guozhong, ImperialCollegePress, 2004.
4. Nanostructured materials, processing, properties and potential applications, Carl C. Koch, Noyes publications, William Andrew publishing, NY, USA, 2002.
5. Environmental application of nanomaterials, GlenE Fryxell, Cao,Guozhong, Imperial CollegePress, 2007.
6. The Physics of Semiconductors: An Introduction including Devices and Nanophysics, Marius Grundmann, Springer-Verlag, Berlin Heidelberg, Germany, 2006.
7. Nanoscale Science and Technology, Eds. R. W. Kelsall, I. W. Hamley and M. Geoghegan, John Wiley & Sons, 2005.
8. Nanotechnology, B. S. Murty, James Murday, and P. Shankar, Springer, 2012.

PHY-709: Physics of Thin Films Credit Hours: 3(3-0)

Introduction:

Thin film, Methods of preparation of films, methods of examination of films, High – energy electron diffraction, Growth and structure of films, films structure,

Properties of Thin Film:

Mechanical properties of films, stress in films formed by thermal evaporation, optical properties of films, Absorbing films, magnetic properties of films, Domains in films, electric properties of films conductive of metal films.

Recommended Books:

1. Thin Film Physics, O. S. Heavens Methuen & Co Ltd, 1989.
2. Handbook of Thin Film Technology, Hartmut Frey, Hamid R. Khan, Springer Science & Business Media, 2015.
3. Thin Film Materials Technology: Sputtering of Compound Materials, Hideaki Adachi and Kiyotaka Wasa, Springer Berlin Heidelberg, 2013.
4. Vacuum Deposition of Thin Films, Holland L. Chapman & Hall 1986.
5. Structure and Properties of thin films, Bean J. W. Wiley New York 1989.

PHY-710 Fundamental Semiconductor Physics Credit Hours: 3(3-0)

The structure and chemistry of semiconductors, and the basic points of band structure, density of states, density of charge carriers in undoped and doped materials (and the temperature dependence thereof), mobility of charge carriers and its temperature dependence. Transport properties and the continuity equations light falling on a semiconductor, the Haynes-Shockley experiment and the p-n junction.

Semiconductor devices:

Manufacturing of semiconductor devices. semiconductor devices and their functionality; bipolar transistors, MOSFETs and other field effect transistors, low dimensional devices, light emitting diodes and diode lasers, photodiodes and radiation detectors, and photovoltaics.

Recommended Books:

1. Semiconductor Physics and Devices, Basic Principles, Donald A. Neamen, McGraw Hill, 2003.
2. Physics of Semiconductor Devices, Massimo Rudan, Springer New York, 2014.
3. Physics of Semiconductor Devices, Simon M. Sze, Kwok K. Ng,John Wiley & Sons, 2006.
4. Semiconductors, N. B. Hannay, Reinhold Publishing Corporation, 1989.
5. Electron and Holes in Semiconductors, W. Shockley, Princeton, D. Van, 1988

PHY-711: Modern Optics and Laser Physics Credit Hours: 3(3-0)

Light-Matter Interactions: The classical propagation of light, optical properties of semiconductors, metals and insulators. Quantum mechanics of the atom-radiation interaction, Einstein A and B coefficients, transition rates, Rabi oscillations and optical linewidths. Radiative and non-radiative decay, luminescence centres, transition series ions.

Laser Physics: History of the laser:

Density of field modes in a cavity, the Fabry-Perot laser, the cold cavity, cavities with gain, laser gain equation, frequency pulling, laser rate equations, threshold inversion, coupled atomic and cavity equations, gain saturation. Cavity modes, cavity geometries, matrix methods and cavity stability. Resonant frequencies. Short pulsed lasers: Q switching and mode locking. Real lasers: gas lasers, solid-state lasers, free electron lasers.

Applications: Laser interferometry optical clocks and laser ranging and position finding.

Non-linear Optics:

The anharmonic oscillator model, phase matching, second and third order non-linearities. Non-linear spectroscopy: ultrafast time domain spectroscopy- pump-probe and four-wave mixing, high frequency resolution spectroscopy- spectral hole burning.

Recommended Books:

1. Gusev V.E., Karabutov. A.A. Laser Optoacoustics. AIP, N.Y., 1993.
2. Almond D.P. Patel J. Photo thermal science and techniques, London, Chapman and Hall, 1996.
3. Introduction to Modern Optics, Grant R. Fowles, Dover Publications New York, 2012.
4. Introduction to Laser Physics, Koichi Shimoda, Springer Verlag Berlin, 2013.

PHY-712: Particle Physics Credit Hours: 3(3-0)

Introduction:

Elementary particle physics, Elementary Particles, Production and Detection of elementary particles, units in particle physics.

Properties and Interactions of Elementary Particles:

Introductory Remarks, Forces, Quantum Numbers, Baryon Number, Lepton Number, Strangeness, Isospin, Gell-Mann-Nishijima Relation, Production and Decay of Resonances, Determining Spins, Violation of Quantum Numbers , Weak Interactions ,Hadronic Weak Decays, Semileptonic Processes, Electromagnetic Processes

Symmetries:

Introductory Remarks, Symmetries in the Lagrangian Formalism, Symmetries in the Hamiltonian Formalism, Infinitesimal Translations, Infinitesimal Rotations, Symmetries in Quantum Mechanics, Continuous Symmetries, Isotopic Spin, Local Symmetries

Discrete Transformations:

Introductory Remarks, Parity, Conservation of Parity, Violation of Parity, Time Reversal, Charge Conjugation, *CPT* Theorem

Formulation of the Standard Model:

Introductory Remarks, Quarks and Leptons, Quark Content of Mesons, Quark Content of Baryons, Need for Color, Quark Model for Mesons, Valence and Sea Quarks in Hadrons ,Weak Isospin and Color Symmetry , Gauge Bosons ,Dynamics of the Gauge Particles, Symmetry Breaking, Chromo dynamics (QCD) and Confinement , Quark-Gluon Plasma

Recommended Books

1. Modern Particle Physics, Mark Thomson, Cambridge University Press, 2013.
2. Introduction to Nuclear and Particle Physics, Second Edition A. Das and T. Ferbel World Scientific 2003.
3. Introduction to elementary Particles David Griffiths, Jhon Wiley and Sons 1987.

PHY-713: Advance Quantum Mechanics Credit Hours: 3(3-0)

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 non conservation; 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. Quantum Mechanics, G. S. Chaddha, New Age International Publishers, 2006.
2. Introduction to Quantum Mechanics, David J. Griffiths, Cambridge University Press, 2016.
3. Advanced Quantum Mechanics J. J. Sakurai and Jim Napolitano, (2nd Edition), 1967.
4. Modern Quantum Mechanics J. J. Sakurai and Jim Napolitano (2nd Edition), Cambridge University Press, 2017.

PHY-714: Quantum Information Theory Credit Hours: 3(3-0)

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-715: Quantum Optics Credit Hours: 3(3-0)

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-716:	Superconductivity	Credit Hours: 3(3-0)

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, M. Tinkham, publishers Dover Publications (Second Edition) 1996.
2. Room-temperature Superconductivity, Andrei Mourachkine, Cambridge International Science, 2004.
3. The Physics of Superconductors, Introduction to Fundamentals and Applications, V.V. Schmidt, publisher Springer Books 1982.
4. Superconductivity of Metals and Alloys, P. G. De Gennes, publishers Westview Press, 1999.

PHY-717:	Medical Physics	Credit Hours: 3(3-0)

Effects of Radiations:

Biological Effects of Radiation, Dose Response Characteristics, Direct and Indirect Action, Acute Effects, Treatment of Acute Overexposure, Delayed Effects, Mental Retardation, Genetic

Effects. Risk Coefficient Estimates: BEIR VII, Cancer Risk Estimates, Genetic Risk Estimates

Radiation Protection and Safety:

Radiation Safety Guides, Organizations That Set Standards, Public Health And Radiation Safety Practice, ICRP Basic Radiation Safety Criteria, Occupational Exposure, Effective Dose, Medical Exposure, Exposure of Individuals In The General Public, Exposure Of Populations, Dose Coefficient, Annual Limit Of Intake,

Interactions of Ionizing Radiation:

Ionization, Photon Beam Description, Photon Beam Attenuation, Attenuation Coefficient, Energy Transfer Coefficient, Energy Absorption Coefficient, Interactions of Photons with Matter, Coherent Scattering, Photoelectric Effect, Compton Effect, Pair Production, Annihilation Radiation, Interactions of Charged Particles, Heavy Charged Particles, Electrons, Interactions of Neutrons

Measurement of Ionizing Radiation:

The Roentgen, Free-Air Ionization Chamber, Thimble Chambers, Chamber Wall, Chamber Calibration, Desirable Chamber Characteristics, Practical Thimble Chambers, Electrometers

Measurement of Absorbed Dose:

Radiation Absorbed Dose, Units for Absorbed Dose, Kerma, Relationship, Between Kerma, Exposure and Absorbed Dose, Calculation of Absorbed Dose from Exposure, Other Methods of Measuring Absorbed Dose: Calorimetry, Chemical Dosimetry, Thermoluminescene Dosimetry (TLD), Photographic Dosimetry, Scientillation Detectors, Other Dosimetric Systems

Modern Radiation Therapy:

3D conformal radiotherapy, Intensity modulated radiotherpy (IMRT), Volumetric arc radiation therapy (VMAT), Brachytherapy, Radioactive Sources, Radium¸ Source Construction, Source Specification, Exposure Rate Constant¸ Radon Hazard, Cesium-137, Cobalt -60, Iridium-192, Gold-198, Iodine--125, Palladium-103

Text/Reference Books:

1. Herman Cember, Introduction to Health Physics, 3rd Ed., (McGraw Hill, New York). 1996.
2. Radiation Physics for Medical Physicists, Ervin B. Podgorsak, Springer International Publishing, 2016.
3. J.R. Williams, D.I. Thwaits, Radiotherapy Physics, (Oxford University Press, New York), 1993.
4. Radiation Protection in Medical Physics, edited by Yves Lemoigne, Alessandra Caner, NATO Science, 2011.
5. Peter Armstrong and Martin L.Wastie, Diagnostic Imaging, 4th ed., (Blackwell Science Ltd., Oxford), 1998.
6. Stewart C.Bushong, Radiologic Science of technologies, 5th ed.,(Mosby), 1993.

PHY-718: Material Preparation and Characterization Techniques Credit Hours: 3(3-0)

Synthesis methods:

Wet chemical methods: Coprecipitation, sol-gel, microwave-assisted, biological synthesis, the rapid solidification process, high-energy ball milling, Solid State reaction method. Chemical vapor deposition: atmospheric pressure chemical vapor deposition, laser chemical vapor deposition, laser chemical vapor deposition. Physical vapor deposition: sputter deposition, electron-beam PVD, thermal evaporation deposition. Synthesis of ceramic nanocomposites: powder process.

Characterization Techniques:
X-ray diffraction (XRD), scanning electron microscope (SEM), EDX transmission electron microscopy (TEM), Atomic force microscopy (AFM), Impedance spectroscopy, Thermogravometric analysis (TGA), Differential scanning calorimetry (DSC), Cyclic voltammetry (CV), Hall measurements, Vibrating sample magnetometer (VSM).

Books Recommended:

1. **Methods of Experimental Physics,** M. I. Pergament, CRC Press, 2014.
2. An Introduction to Experimental Physics, Colin Cooke, UCL press, 2005.
3. J. Gibbons, Semi-conductor Electronics, McGraw-Hill, 1962.
4. Elements of X-Ray Diffraction, B. D. Cullity, 1956.
5. Materials characterization techniques. Sam Zhang, Lin Li, Ashok Kumar, Boca Raton: CRC Press (2009).

PHY-719: Condensed Matter Theory-II Credit Hours: 3(3-0)

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; 1st 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-720: Introduction to Polymers, Ceramics and Composites Credit Hours: 3(3-0)

Introduction to Polymers, Classification of Polymers, Addition and Condensation Polymerization, Typical Thermoplastics, Structure-Property Relationship in Typical Thermoplastics, Effect of Temperature on Thermoplastics, Mechanical Properties of Thermoplastics, Elastomers, Thermosetting Polymers, Adhesives, Polymer, Processing and Recycling, Copolymers, Biological Molecules, Ceramics, Introduction to Ceramics, Application of Ceramics, Properties of Ceramics, Synthesis and Processing of Ceramics, Characteristics of Sintered Ceramics. Inorganic Glasses, Glass Ceramics, Processing and Application of Clay Products, Refractories. Composites, Dispersion Strengthening, Particulate Composites, Fiber-reinforced Composites, Characteristics, Manufacturing, and Applications of fiber-reinforced Composites, Laminar Composite Materials and Sandwich Structures.

Books

1. Essentials of Materials Science and Engineering, Second Edition, Donald R. Askeland, Pradeep P. Fuley, Cengage Learning, 2016.
2. Materials Science and Engineering, An Introduction, W.D. Callister, Jr., publisher John Wiley & Sons Inc (2007).
3. The Physics and Chemistry of Materials, J. I. Gersten and F.W. Smith, publisher John Wiley & Sons Inc (2001).
4. Fundamentals of Ceramics, M.W. Barsoum, IOP Publishing Ltd (2003)
5. The Physics of Amorphous Solids, by Richard Zallen, Publisher John Wiley & Sons Inc. (1998).
6. An Introduction to Polymer Physics, D.I. Bower, Publisher Cambridge University Press, Cambridge (2002).

PHY-721 Theory of Dielectric Materials Credit Hours: 3(3-0)

The potential due to a dipole, Dipole moment of a spherical charge, Laplace's equation, The tunneling phenomenon, Band theory of solids, The boltzmann factor, Polarization and static dielectric constant, Electronic polarization, The internal field, Orientational polarization, Debye equations, Spontaneous polarization, Complex permittivity, Polarization build up, Debye equations, Cole-cole relaxation, Dielectric susceptibility, Distribution of relaxation times, Kramer-kronig relations, Loss factor and conductivity, Dielectric loss and relaxation, Jonscher's universal law, Cluster approach of dissado-hill, Equivalent circuits, Interfacial polarization, The absorption phenomenon, Frequency dependence of ε

Books Recommended:

1. H. Frölich, Theory of Dielectrics Clarendon Press, 1949
2. Solid State Physics 8thed., Charles Kittel, John Wiley & Sons 1989.
3. Principles of Solid State Physics, Aimen, John Wiley & Sons, 1988.
4. Solid State Physics, Blakemore, N. B. Sounders Company, 1989.
5. Dielectrics in Electric Field, Gurur G. Raju, Marcel Dekker, Inc. 2003

PHY-722 Biomass Technologies Credit Hours: 3(3-0)

Biomass Resources and Energy Crops, Chemical and physical properties of biomass, Characteristics of biomass as a fuel, Comparison to conventional fuels (coal, oil, natural gas), Energy crops for bio-energy production, Pre-processing of biomass fuel for pyrolysis/ gasification, Principles of thermo-chemical conversion processes, Pyrolysis, Gasification, Combustion, Co-firing, Energy conversion systems and CHP, Gasification Technologies, Design and Manufacturing of gasifiers, Design Challenges, Batch reactors, Continuous reactors, Multi-stage gasification, Catalytic gasification, Gasification Catalysts, steam gasification, Characterization of fresh and spent catalysts, synthesis gas (producer gas) and its characterization, Process parameters influencing syngas composition, process optimization, state of the gasification technology, downstream processes and challenges

Recommended Books:

1. Introduction to Biomass Energy Conversion by Sergio C. Capareda (CRC Press) 2014
2. Biomass Gasification and Pyrolysis: Practical Design and Theory by Prabir Basu (Academic Press) 2010
3. Hydrogen and Syngas Production and Purification Technologies by Ke Liu, Chunshan Song, Velu Subramani (John Wiley & Sons) 2009
4. Reaction Pathways and Mechanisms in Thermocatalytic Biomass Conversion (I &II) by Marcel Schlaf, Zonghcao Zhang (Springer) 2015
5. Biomass Power for the world by Wim P. M. van Swaaij, Sascha R. A. Kersten, Wolfgang Palz (Pan Stanford Publishing) 2015

PHY-723 Advanced Solid State Physics-I 3(3-0)

Course objective:

The objective of this course is to provide the sound background of the solid state phenomena such as, Brillouin Zones, Density of states, Energy band structure, polarons, plasmons etc.

Course outlines:

Bloch’s theorem and Brillouin Zones, Zones Scheme, Electronic density of States, Band theory of Solids, Hartree approximation, Nearly free electron model, Tight binding methods, Cellular methods, Augmented plane waves, Orthogonal plane wave, pseudo-potential technique and model potentials, Electron-Phonon interaction: Polarons, electron-electron interaction: Fermi Liquid, Plasmons, Fermi surface studies, High Magnetic fields, Dynamics of electrons, Cyclotron resonance, High field magneto-resistance, Open orbits, Magneto-acoustic Oscillations, D-Hass van Alphen effect.

Recommended Books:

1. R.E. Periarls, The Quantum Theory of Solids, Volume-1(Perfect Lattice in Equilibrium), Oxford University Press, USA (1996).

2. R.E. Periarls, The Quantum Theory of Solids, Volume-2(Non- Equilibrium and Disorder), Oxford University Press, USA (1985).
3. Phillips, P. Advanced Solid State Physics (2nd ed.). (2012). Cambridge: Cambridge University Press.
4. Thomas Pruschke, "Advanced Solid State Theory", (Morgan & Claypool Publishers, 2014).
5. C. Kittle, Quantum Theory of Solids, John-Wiley and Sons (1986).
6. M. Jones and N.H. March, Theoretical Solid State Physics, Wiley Interscience (2011).
7. C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 8th.Ed., (2014)

PHY-724 Advanced Solid State Physics-II 3(3-0)

Course objective:

The objective of this course is to provide the core knowledge of the solid-state phenomena such as, Optical processes, magnetism, Superconductivity etc.

Course outlines:

Optical processes and Excitons, Multi-phonon processes, Interband transitions, Interaction with conduction electrons, anomalous skin effect, Ultrasonic attenuation, Raman effect in crystals, Magnetism including paramagnetism, diamagnetism, ferromagnetism, antiferrromagnetism and magnons, magnetism in single domain particle including geomagnetism, magnetism in single domain particle including biomagnetism, Superconductivity, Meissner effect and London Equations, electron-electron interactions (cooper pair), BCS theory and Ginsburg-Landau theory, Josephson superconducting tunneling. Application of Solid State Physics in Electronic devices, Optical devices such as lasers and fibre optics, Silicon-based logic and memory bits

Recommended Books.

1. R.E. Periarls, The Quantum Theory of Solids, Volume-1(Perfect Lattice in Equilibrium), Oxfored University Press, USA (1996).
2. R.E. Periarls, The Quantum Theory of Solids, Volume-2(Non- Equilibrium and Disorder), Oxfored University Press, USA (1985).
3. J.M. Ziman, Principles of the theory of solids, Cambridge University Press(1972).
4. P.T. Landsberg and D.A. EVANS, Solid State Theory, John-Wiley and Sons (1969).
5. C. Kittle, Quantum Theory of Solids, John-Wiley and Sons (1986).
6. M. Jones and N.H. March, Theoretical Solid State Physics, Wiley Interscience (2011)
7. C. Kittel, Introduction to Solid State Physics, John Wiley & Sons, 8th.Ed., (2014)

PHY-725 Imaging and characterization techniques for nanostructures 3(3-0)

Course objectives

Nanostructure and nanomaterials have interesting specific properties arising from their low dimensionality and from increased influence of the surface. The course outlines highlight the main methods of characterization at nanoscale that can be achieved by variety of electron, ion beam and scanning probe methodologies. Furthermore, the course survey a range of currently employed methods for advanced chemical analysis of elements and molecules in solids, complementing to other methods.

In-depth treatment is not possible within this course, students are expected to learn the standard application of spectroscopic, microscopic and chemical characterization tools in literature, and after attending the course the students should be able to identify the proper tool for particular problem.

Course outlines:

Introduction, Light microscopy, scanning electron microscopy, Scanning tunneling microscopy, Electron energy-loos spectroscopy, Cathode-Luminescence, Scanning Transmission electron microscope. Introduction, X-Ray scattering, Auger electron diffraction (XPD and AED), X-Ray photoelectron and low energy electron diffraction, Reflection High-energy electron diffraction (RHEED), Ion scattering spectroscopy, Rutherford Backscattering spectroscopy, Introduction, X-Ray photoelectron spectroscopy, UV photoelectron spectroscopy, Auger electron spectroscopy, x-ray-absorption and extended x-ray-absorption fine-structure (EXAFS), Introduction, Photoluminescence, FTIR spectroscopy, Ramman Spectroscopy, Solid state Nuclear magnetic resonance, Inelastic electron tunneling spectroscopy

Recommended Books:

1. Elements of X-ray Diffraction, by B. D. Cullity, Addison Wesley Publishing Company, Philippines, 2000.
2. Encyclopedia of Materials Characterization, C. Richard Brundle, Charles k Evans, Jr., and Shaun Wilson, MATERIALS CHARACTERIZATION SERIES, 2003
3. Energy-Dispersive X-Ray Analysis in the Electron Microscope, A.J.Garratt-Reed and D.C.Bell, BIOS Scientific Publishers Limited, 2003
4. Electron Microscopy Principles and Fundamentals, Edited by, S. Amelinckx, D. van Dyck, J. van Landuyt , G. van Tendeloo, VCH VerlagsgesellschaftmbH, D-69451Weinheim (Federal Republic of Germany), 1997

5. Physical Methods for Materials Characterization, P E J Flewitt and R K Wild, IOP Publishing Ltd. 2nd edition 2003.

PHY-726 Theory of Magnetic Materials Credit Hours 3(3-0)

Course objectives

This course is a rigorous survey of magnetism in condensed matter. It will connect the phenomenon of magnetism and its various manifestations to atomic and electronic systems and their interactions. The electronic systems could be localized or itinerant. This course discusses the origins of magnetism within angular momentum and enables students to start exploring the magnetism of isolated systems. Moreover, these angular momentums assemble into crystal structures and mark the impact of crystal environments and interactions on these angular momentums. The detailed discussion is made on the exchange interaction and how the interplay of exchange effects and crystal structure leads to long range magnetic order of multiple kinds. In addition, order and broken symmetry are investigated along with specific examples of magnetism in metals.

Course outlines:

Magnetic moments, classical mechanics and magnetic moments, quantum mechanical spin and magnetic moments. An atom in a magnetic field, magnetic susceptibility, diamagnetism, Paramagnetism, ground state of an ion and Hund's rules, Nuclear spins. Origin of crystal fields, Orbital quenching, The Jahn – Teller effect**,** Magnetic dipolar interaction, exchange interactions (origin of exchange, direct exchange, indirect exchange, double exchange, anisotropic exchange interaction), ferromagnetism, antiferromagnetism, ferrimagnetism, helical order, spin glasses, nuclear ordering, Broken symmetry, Heisenberg, Ising models, magnons, The free electron model, Landau levels, Landau diamagnetism, Pauli paramagnetism, RKKY interactions, Y-K angle, spin density waves, Kondo effect, Hubbard model.

Recommended Books

1. B.D. Cullity, Introduction to Magnetic Materials, IEEE press 2nd edition (2009).
2. N. Spaldin, Magnetic Materials, Cambridge university press 2nd edition (2003).
3. S. Blundell, Magnetism in condense matter, oxford university press (2001).
4. D. Jiles, Introduction to Magnetism and Magnetic, John Wiley & Sons, INC 2nd edition (2000).

5. ROBERT C. O'HANDLEY, Modern Magnetic Materials Principles and Applications, John Wiley & Sons, INC 2nd edition (2000).

PHY-727 Nano photonics and Metamaterials Credit Hours: 3(3-0)

Course objective:

The aim of this graduate course is to provide necessary knowledge of the field of Nanophotonics and Metamaterials to understand its applications in science and engineering.

Course outlines:

Plasmonics and Metamaterials, Review of Background Material**,** Electromagnetics of Metals, Surface Plasmon at Metal / Insulator Interface, Excitation of Surface Plasmon, Nanoparticles and Nanorods, Plasmon Waveguide (MIM and IMI), Plasmonic Lens, Introduction to Metamaterials, Optical Transformation Theory, Fundamentals of Transmission-Line Metamaterials, Theory and Design of Metamaterials, Metamaterials cloaking, Metamaterials based enhanced energy harvesting, Future Research in Plasmonics and Metamaterials

Recommended Books

1. Stefan A. Maier "Plasmonics: Fundamentals and Applications", Springer Science, 2007.
2. Laszlo Solymar and Ekaterina Shamonina, "Waves in Metamaterials", Oxford University Press, 2014
3. Editors Tie Jun Cui, David R. Smith and Ruopeng Liu, "Metamaterials Theory, Design, and Applications", Springer 2010.
4. Craig F. Bohren, Donald R. Huffman, " Absorption and Scattering of Light by Small Particles", John Wiley & Sons, 1998.
5. Constantine A. Balanis, "Advanced Engineering Electromagnetics", 2nd Edition, John Wiley & Sons, 2012.
6. Electromagnetic Metamaterials: The Engineering Approach by Christophe Caloz and Tatsuo Itoh
7. W. H. Hayt, J. A. Buck, M. Jaleel Akhtar, "Engineering Electromagnetics" Mc Graw Hill, 8th Edition, 2014.
8. Other references (books, papers etc) will be given during course of studies

PHY-728 Luminescence of Solid Materials Credit Hours: 3(3-0)

Objectives:

- To acquaint the students with different types of Luminescence process
- Learn about defect through Luminescence
- To apply Luminescence spectroscopy in practical research

Course Contents

Theory of luminescence, Characteristics of Luminescence, Fundamentals of the Quantum theory of radiation, Theoretical model and mechanism of luminescence, Experimental techniques of luminescence measurements, Absorption and luminescence spectroscopy, Spectroscopic components, Time-resolved spectroscopy, Hole-burning, Fluorescence line-narrowing and Photon echo, Quantum efficiency and nonradiative processes, New developments, Photoluminescence, Classification of photoluminescence in solids, Band to band luminescence, Wannier exciton luminescence, Characteristics of localized center luminescence, Extrinsic luminescence of unlocalized type, Extrinsic luminescence of localized type, Thermoluminescence, Thermoluminescence model, Thermoluminescence mechanism, Methods of analysis, Applications.

Recommended Books:

1. Luminescence Materials KGaA, Weinheim, Springer Germany, 2008
2. Luminescence - An Outlook on the Phenomena and their Application. Thirumalai, J. London Intech Open. 2016
3. Luminescence of Solids,D. R. Vij, Plenum Press New York, 1998.
4. Luminescence, From Theory to Applications R. Ronda WILEY-VCH Verlag GmbH & Co. 2007

PHY-729 Functional Materials and Devices Credit Hours: 3(3-0)

Objectives:

- To learn about the properties of smart/functional materials used in modern electronic devices.
- To familiarize students with the crystal structures, bonding, and physical properties of materials and their applications.
- To learn about the relationship between crystal structure and properties.

Course Contents

Trends in Periodic Table and Basic Concepts and Bonding: Physical and Chemicals Properties of Cations and Anions, Coordination Chemistry, Atomic Radius, Ionic Radius Classification of Functional Oxides by Function: Dielectrics materials Dielectric Constant, Dielectric Loss/Dissipation Factor, Strength and Breakdown Mechanisms, Paraelectric Material: Paraelectricity, Microwave dielectrics and their properties, Microwave Telecommunication, Ferroelectric Materials: Ferroelectricity, Ferroelectric response with respect to temperature, Curie Point, Domains and Hysteresis Piezoelectric Materials: Piezoelectricity/Piezoelectric Effect, Polarization and strain vs. electric field (E), Piezoelectric Coefficients, Piezoelectrics for sensors and actuators Magnetic Materials: Background, ferrites, magnetic properties and applications. Thermoelectric Materials: Thermoelectricity, Seebeck effect, Pelteir Effect, Thermoelectric power generation and cooling, Defects versus Thermoelectric Properties and Applications

Recommended Books

1. K.M. Nair, A. Bhalla, l. K. Gupto, S. Hirano, B. V. Hiremath, l. Jean, R. Pohanka, Dielectric Materials and Devices, 1999, The American Ceramics Society.
2. K. C. Kao, Dielectric phenomena in solids, 2004, Elsevier
3. M. T. Sebastian, Dielectric Materials for Wireless Communications, 2007, Springer
4. Moulson A. J. and J.M. Herbert J. M., “Electro ceramics: Materials, Properties, and Applications”. 2nd ed. John Wiley & Sons Ltd, England, 2003
5. Richard J. D. Tilley, Perovskites: Structure–Property Relationships, 2016 John Wiley & Sons, Ltd
6. Julian Goldsmid, The Physics of Thermoelectric Energy Conversion, Morgan & Claypool Publishers, 2017

PHY-730 Atomistic Simulations of Materials Credit Hours: 3(3-0)

Objectives

This course will provide an introduction to materials modeling and density functional theory (DFT) based simulations of structural, electronic, chemical, magnetic, thermodynamic, and other properties of solids. In addition, the basic knowledge of quantum mechanical simulations, computer programming, linux operating systems, and computational software will be covered in this course, followed by the hands on tutorials on electronic structure calculations of bulk (e.g. silicon) and two-dimensional materials (e.g. graphene). At the end of this course, the students will be able to model a system and calculate its ground state atomic structure and related properties.

Contents

Schrodinger total energy, different contributions to total energy,historic development of density functional theory, accuracy, ,Kohn-Sham theorems, Born-Oppenheimer approximation, exchange-correlation effects, actual potential vs. pseudopotential, projector augment plane waves, ground state energy, local density approximation (LDA), generalized gradient approximation (GGA), total energy minimization,reliability and applications of DFT in materials science, comparison between DFT and experimental results,types of DFT simulation packages; Vienna Ab-initio simulation package (VASP), WIEN2k, and quantum espresso, different approaches to the accurate determination of lattice constants and electronic band gaps, treatment of strongly correlated magnetic systems, Van der Waals interactions, computational scaling of DFT simulations.

Hierarchical structure of VASP and WIEN2k code, input files; POSCAR, POTCAR, KPOINTS, INCAR, input parameters in INCAR file, symmetry points in KPOINTS file for band-structure calculation, energy minimization methods, spin-polarization calculation parameters, force tolerance criterion, self-consistent and non-self-consistent calculations, geometry optimization including lattice vectors and atomic positions, how to find the true ground state, density of states (DOS) and electronic band structure calculations, hands on tutorials on the calculation of structural and electronic properties of bulk silicon (Si), GaAs, Fe, Co, Ni, simulation of simple cubic (SC), face-centered cubic (FCC) and body centered cubic (BCC) crystals, calculation of electronic properties of graphene, and related two-dimensional (2D) materials.

Recommended Books

1. David S. Sholl, Janice A. Steckel, “Density Functional Theory: A Practical Introduction”, 2009, John Wiley & Sons, Inc.

2. Feliciano Giustino, “Materials Modelling using Density Functional Theory”, Oxford University Press

3. Richard Martin, “Electronic Structure”, Cambridge University Press

4. EfthimiosKaxiras, “Atomic and Electronic Structure of Solids”, Cambridge University Press

5. Jorge Kohanoff, “Electronic Structure Calculations for Solids and Molecules”, Cambridge University Press

PHY-731 Renewable Energy Sources Credit Hours: 3(3-0)

Course Contents

Introduction, importance of energy, world energy demand, conventional energy sources, renewable energy sources; potential, availability and present status of renewable energy sources, solar energy, physical principle of the conversion of solar radiation into heat, flat plate collectors, concentrating collectors, basic principles and components of wind energy conversion systems, types and performance of wind machines, biomass conversion technologies, classification of biogas plants, geothermal sources, hydrothermal, geo-pressure, petro-thermal and magma resources, advantages and limitations of geothermal energy, introduction, global generation, growth rate, prospects of nuclear, safely and health hazards issues, global resources and their assessment, classification, micro, mini, small and large resources, principles of energy conversions, turbines, working and efficiency of from micro to small power systems, fuel cell and thermoelectricity, environmental impact.

Recommended Books:

1. Solar Energy Utilization by G.D. Rai, (Khanna Publishers SC Delhi, 1991).
2. Renewable Energy Sources by John Twidell and Tony Weir, (Routledge, 3rd edition, 2015).
3. Solar Engineering Technology by Ted. J. Jansen, (Prentice Hall, 1985).
4. Wind Power by V. Daniel Hunt, (Litton Educational Publishing Inc, 1981).
5. Solar Hydrogen Energy Systems by Ed. T. Ohta, (Pergamon Press, 1979).
6. Solar Energy Conversion by Eds., A,E. Dixon and J.D. Leslie, (Pergamon Press, 1979).
7. Biogas, Production and Utilisation by Elizabeth C. Price, Paul N. Cheremisinoff, (Ann Arbor Science, USA, 1981).
8. Biomass, Catalysts and Liquid Fuels by Ian Campbell, (Technonic Publishing Co. Inc, USA, 1983).

PHY-732: Materials Science-II Credit Hours: 3(3-0)

Outlines:

Atom and ion movements in materials: Diffusion, mechanisms for diffusion, activation energy for diffusion, factors affecting diffusion, diffusion and materials processing. Fracture mechanics, fatigue, and creep behavior: Fracture mechanics, importance of fracture mechanics, micro-structural features of fracture in ceramics, glasses, and composites, fatigue, fatigue testing, creep, stress rupture, and stress corrosion. Mechanical properties: Stress-strain diagram, properties obtained from the tensile test, hardness of materials, strain rate effects and impact behavior. Strain hardening and annealing: Relationship of cold working to the stress-strain curve, strain-hardening mechanisms, characteristics of cold working, stages of annealing, control of annealing, annealing and materials processing, hot working. Glasses, ceramics, polymers and composite materials

Recommended Books:

1. Materials Science and Engineering, An Introduction, W.D. Callister, Jr., publisher John Wiley & Sons Inc (2007).
2. The Physics and Chemistry of Materials, J. I. Gersten and F.W. Smith, publisher John Wiley & Sons Inc (2001).
3. Fundamentals of Ceramics, 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, M. Ohring, (2nd edition) Publishers Academic Press (2002).
7. Soft Condensed Matter, R.A. L. Jones, Publishers Oxford University Press(2002).

PHY-733 Plasma Spectroscopy and Applications Credit Hours: 3(3-0)

Course Contents:

Laser-matter interaction and its quantum mechanical description, Fundamentals of LIBS, Laser ablation, Physics of plasma in LIBS, Kinetics of the population of atomic levels in plasma, Radiative and non-radiative processes in plasma, Expansion and decay of plasma, Line and continuum radiations, Line broadening mechanisms, Spatial and temporal distribution of laser-induced plasma, Characterization of laser-induced plasma, LIBS signal enhancement mechanisms, Theoretical model for double pulse laser induced breakdown Spectroscopy, univariate and multivariate calibration strategies, Analytical applications of LIBS, Calibration curves, and calibration-free LIBS techniques, chemo-metric methodologies such as partial least square regression analysis and Principal component analysis (PCA) for the classification of LIBS spectra, Femtosecond LIBS, Micro LIBS, Standoff LIBS, and Nano enhanced LIBS.

Recommended Text:

1. Jagdish Singh Surya Thakur, Laser-Induced Breakdown Spectroscopy, 2nd Edition, Elsevier Science, USA (2020)
2. Sergio Musazzi, Umberto Perini (Eds.), Laser-Induced Breakdown Spectroscopy: Theory and Applications, Springer- Verlag Berlin Heidelberg (2014)
3. Reinhard Noll, Laser-Induced Breakdown Spectroscopy: Fundamentals and Applications, Springer, New, New York (2012).

PHY-734 Advanced Laser Physics Credit Hours 3(3-0)

Course Contents

Basic Concepts:

Introduction and Brief History, Basic Principle of Lasers, Active Medium, Energy levels, Transitions, Types of Transitions, Spontaneous Emission, Stimulated Emission, Absorption, The Einstein Relations, Laser Pumping, Population Inversion, Optical Resonator, Amplification of Light, Optical Feedback

Pumping Processes:

Pumping Mechanisms, Chemical Pumping, Gas Dynamic Pumping, Nuclear Pumping, Optical Pumping, Laser Pumping, Flash lamp Pumping, Electrical Pumping, Physical Characteristics of Discharges, Steady State Laser Pumping and Population Inversion, Elementary Four-Level Laser System, Four-Level Pumping Analysis, Fluorescence Quantum Efficiency, Four-Level Population Inversion, Three-Level Laser System, Laser Gain Saturation, Laser Gain Saturation Analysis

Optical Resonators and Laser Modes:

Symmetric Resonators, Hemispherical Resonators, Unstable Resonator, Optical Resonators, Resonator "g" Parameters, Stable Systems, Unstable Systems, Stability Diagram, Important

Resonators Types, Symmetric Resonators, Symmetric Confocal Resonator, Long Radius (Near-Plane) Resonators, Near-Concentric Resonators, Hemispherical Resonators, Concave-Convex Resonators, Unstable Confocal Resonator, Laser Modes, Longitudinal Modes, Longitudinal-Transverse Modes, Single Mode Operation,

The Laser Output:

Line shape Function, Natural Broadening, Doppler Broadening, Collision Broadening, Homogeneous and Inhomogeneous Broadening, Q-Switching, Rotating Mirror Q-Switch, Electro-Optic Q-Switch, Passive Q-Switch, Laser Beam Properties, Monochromaticity, Coherence, Directionality, Focusing Properties of Laser Radiation, Brightness.

Laser Systems:

Classes of Lasers, Gas Lasers, Helium-Neon Laser, Pumping Mechanism, Suppression of the Oscillations other than 632.8 nm 8.4, Selection of Different Visible Wavelengths, Output Power versus Current, Output Power versus Output Mirror Transmission, Mirror Arrangements, Gain Diameter Relationship, Longitudinal Modes, Transverse Modes, Liquid Dye Lasers, Energy Level Diagram, Effects of the presence of T1 and T2 States, Pumping Sources, Tuning Ranges Solid-State Lasers, The Nd: YAG Laser, Yttrium Aluminum Garnet, Pumping Mechanisms Energy Level Diagram, Nd-Laser Resonators, Output Power, Oscillator-Amplifier Configurations, Efficiency, Cooling, Safety.

Laser Applications:

Holography, Difference of Holograms and Photographs, The Principle of Holography, Construction and Reconstruction of Holograms, Laser Doppler Anemometer Experimental Set-up for A Laser Doppler Anemometer, Doppler Shift Caused by a Moving Scattering Centre, Medical Applications of Lasers, Brief History, Drawbacks of the use of Scalpel, Removal of Tissue by Laser Surgery, Lasers in Ophthalmology, Treatment of Detached Retina, Cataract Surgery, Corneal Sculpting, Lasers in Dermatology, Treatment of Port-Wine Stains, Optical Fiber-based Surgical Laser Systems, Laser-Tissue Interaction, Shattering of the Stones, Cancer Treatment.

<u>Recommended Books:</u>

1. Orazio Svelto, Principles of Laser, 5th Edition, Springer, 2010.
2. H.J. Eichler, B. Eppich, J. Fischer, R. Güther, G.G. Gurzadyan, A. Hermerschmidt, A. Laubereau, V.A. Lopota, O. Mehl, C.R. Vidal, H. Weber, B. Wende, Laser Physics and Applications, Springer New York 2004.
3. J. D. Harvey, D. F. Walls, Laser Physics, Springer, New York 1983.

PHY-735: Two-dimensional Materials and Applications Credit Hours: 3(3-0)

<u>Course Contents</u>

Introduction of different types of 2D materials beyond graphenes, such as transition metal dichalcogenides, phosphorene, MXenes etc., T-type and H-type structures, buckled and puckered arrangement, inter-layer and intra-layer forces, isolation of monolayer structure from bulk counterpart, physical properties of 2D materials such as phase transformations, spin-polarization, magnetism, atomic and electronic structure, formation of 2D-heterostructures and their physical properties, strategies and challenges of 2D materials synthesis.

Surface properties of 2D materials, physisorption, chemisorption, work function, charge transfer, adsorption energy, design of the adsorbent-adsorbate system, chemiresistive sensors, electrochemical sensors, understanding the adsorption mechanism of molecules via density functional theory-based numerical simulations, optimization of sensor sensitivity and selectivity via strain, chemical doping, applications sensors to biological and environmental applications, electrochemistry of 2D materials for energy storage applications.

Recommended Books

1. Advanced 2D Materials, Ashutosh Tiwari, Mikael Syväjärvi, John Wiley & Sons, 1st edition, 2016.
2. 2D Materials: Properties and Devices, Phaedon Avouris, Tony F. Heinz, Tony Low, Cambridge University Press, 1st edition, 2017.
3. Fundamentals and sensing applications of 2D materials, Rout, Chandra Sekhar, Dattatray J. Late, and Hywel Morgan, Woodhead Publishing, 1st edition, 2019.

SCHEME OF STUDIES FOR B.S. PHYSICS

Duration	8-12 Semesters
Major Courses	91 Credits
General Education	30 Credit
Interdisciplinary	12 Credits
Internship	03 Credits
Project	03 Credits
Total Credit Hours	145 Credits
Comprehensive Oral Examination	Satisfactory/Unsatisfactory Basis

Admission Criteria:

- Intermediate (Physics as a compulsory subject) with at least 2nd division *OR* DAE (3 years diploma with Physics and Mathematics).
- Overall merit comprises the academic record.

Semester-I			
Course Code	Course Title	Credit hours	Category
GEN-3101	Islamic Studies	2(2-0)	General
GEN-3102	Functional English	3(3-0)	General
GEN-3103	Environmental Science	3(2-1)	General
MATH-3104	Calculus-I	3(3-0)	Major
MATH-3105	Vector Mechanics and Statics	3(3-0)	Major
PHY-3106	Mechanics and Theory of Relativity	3(2-1)	Major
PHY-3107	Physics Lab-I	1(0-1)	Major
Total		***18(16-2)***	
Semester-II			
Course Code	Course Title	Credit hours	Category
GEN-3201	Arabic/History of Kashmir/History of Islam	2(2-0)	General
GEN-3202	Quantitative Reasoning-I	3(3-0)	General
GEN-3203	Expository Writing	3(3-0)	General
MATH-3204	Calculus-II	3(3-0)	Major
MATH-3205	Introduction to Linear Algebra	3(3-0)	Interdisciplinary
PHY-3206	Electricity and Magnetism	3(3-0)	Major
PHY-3207	Physics Lab-II	1(0-1)	Major
Total		***18(17-1)***	
Semester-III			

Course Code	Course Title	Credit hours	Category
GEN-4301	Applications of Information and Communication Technologies	3(2-1)	General
GEN-4302	Quantitative Reasoning-II	3(3-0)	General
GEN-4303	Civics and Community Engagement	2(2-0)	General
MATH-4304	Calculus-III	3(3-0)	Major
MATH-4305	Numerical Analysis-I	3(3-0)	Interdisciplinary
PHY-4306	Waves, Oscillations and Thermodynamics	3(2-1)	Major
PHY-4307	Physics Lab-III	1(0-1)	Major
Total		***18(16-2)***	

Semester-IV

Course Code	Course Title	Credit hours	Category
GEN-4401	Introduction to Sociology	2(2-0)	General
GEN-4402	Ideology and Constitution of Pakistan	2(2-0)	General
GEN-4403	Entrepreneurship	2(2-0)	General
MATH-4404	Ordinary Differential Equations	3(3-0)	Interdisciplinary
MATH-4405	Mathematical Computing	3(3-0)	Interdisciplinary
PHY-4406	Modern Physics and Electronics	3(2-1)	Major
PHY-4407	Physics Lab-IV	1(0-1)	Major
Total		***16(15-1)***	

Semester-V

Course Code	Course Title	Credit hours	Category
PHY-5501	Lab-V (Electronics)	3(0-3)	Major
PHY-5502	Classical Mechanics	3(3-0)	Major
PHY-5503	Methods of Mathematical Physics - I	3(3-0)	Major
PHY-5504	Electromagnetic Theory-I	3(3-0)	Major
PHY-5505	Electronics	3(3-0)	Major
PHY-5506	Atomic and Laser Physics	3(3-0)	Major
Total		***18(15-3)***	

Semester-VI

Course Code	Course Title	Credit hours	Category
PHY-5601	Lab -VI (Solid State Physics)	3(0-3)	Major
PHY-5602	Quantum Mechanics-I	3(3-0)	Major
PHY-5603	Methods of Mathematical Physics-II	3(3-0)	Major
PHY-5604	Electromagnetic Theory-II	3(3-0)	Major
PHY-5605	Nuclear Physics-I	3(3-0)	Major
PHY-5606	Solid State Physics-I	3(3-0)	Major
Total		***18(15-3)***	

Semester-VII			
Course Code	Course Title	Credit hours	Category
PHY-6701	Lab-VII (Nuclear Phys.)	3(0-3)	Major
PHY-6702	Quantum Mechanics-II	3(3-0)	Major
PHY-6703	Plasma Physics	3(3-0)	Major
PHY-6704	Internship	3(0-3)	Major
PHY-6705	Nuclear Physics-II	3(3-0)	Major
PHY-6706	Solid State Physics-II	3(3-0)	Major
Total		***18(15-3)***	
Semester-VIII			
Course Code	Course Title	Credit hours	Category
PHY-6801	Lab-VIII (Modern Physics)	3(0-3)	Major
PHY-6802	Statistical Mechanics and Thermal Physics	3(3-0)	Major
PHY-6803	Computational Physics	3(2-1)	Major
PHY-6804	Capstone Project*	3(3-0)	Major
Optional Course Code	Optional Course (See Below)	3(3-0)	Major
PHY-6800	Comprehensive Viva	S/U	
Total		***15(12-3)***	
Optional Courses			Category
PHY-6805	Magnetism in Condensed Matter	3(3-0)	Major Optional
PHY-6806	Environmental Physics	3(3-0)	Major Optional
PHY-6807	Renewable Energy Sources	3(3-0)	Major Optional
PHY-6808	Radiation and Medical Physics	3(3-0)	Major Optional
PHY-6809	Experimental Plasma Physics	3(3-0)	Major Optional
PHY-6810	Introduction To Particle Physics	3(3-0)	Major Optional
PHY-6811	Computer Simulation	3(2-1)	Major Optional

Note: Students can choose one optional paper from the above list in the 8th semester. This option will be subject to the availability of qualified staff and will be decided at a staff meeting held two weeks before the commencement of the semester.

*The capstone project will be assigned to the students in the 7th semester, and the students shall start work on capstone project in the same semester.

COURSE CONTENTS OF BS (4 years) PROGRAM

Semester-I

GEN-3101 Islamic Studies Credit Hrs. 2(2-0)

Course Objectives

This course is aimed as

1. To provide Basic information about Islamic Studies
2. To enhance the understanding of the students regarding Islamic Civilization
3. To improve student's skills in performing prayers and other worship
4. To enhance the skills of the students for understanding issues related to faith and religious life.

Course contents

Basic Concepts of Quran, History of Quran, Uloom-ul-Quran, Verses of Surah Al-Baqra Related to Faith(Verse No-284-286), Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11), Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77), Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154), Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56, 57,58.), Verses of Surah Al-Hashar (18,19,20),Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14), Life of Muhammad Bin Abdullah (Before Prophet Hood), Life of Holy Prophet (S.A.W) in Makkah, Important Lessons Derived from the life of Holy Prophet in Makkah,Life of Holy Prophet (S.A.W) in Madina, Important Events of Life Holy Prophet in Madina, Important Lessons Derived from the life of Holy Prophet in Madina ,Basic Concepts of Hadith, History of Hadith, Kinds of Hadith, Uloom-ul-Hadith, Sunnah & Hadith, Legal Position of Sunnah, Basic Concepts of Islamic Law & Jurisprudence, History & Importance of Islamic Law & Jurisprudence, Sources of Islamic Law & Jurisprudence, Nature of Differences in Islamic Law, Islam and Sectarianism, Basic Concepts of Islamic Culture & Civilization, Historical Development of Islamic Culture & Civilization, Characteristics of Islamic Culture & Civilization, Islamic Culture &

Civilization and Contemporary Issues, Basic Concepts of Islam & Science, Contributions of Muslims in the Development of Science, Quranic & Science, Basic Concepts of Islamic Economic System, Means of Distribution of wealth in Islamic Economics, Islamic Concept of Riba, Islamic Ways of Trade & Commerce, Basic Concepts of Islamic Political System, Islamic Concept of Sovereignty, Basic Institutions of Govt. in Islam, Period of Khlaft-E-Rashida, Period of Ummayyads, Period of Abbasids, Basic Concepts of Social System of Islam, Elements of Family, Ethical Values of Islam.

Reference Books:

1. Hameed ullah Muhammad, "Emergence of Islam", IRI, Islamabad
2. Hameed ullah Muhammad, "Muslim Conduct of State"
3. Hameed ullah Muhammad, 'Introduction to Islam
4) Mulana Muhammad Yousaf Islahi,"
1. Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
2. Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993).
3. Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
4. H.S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
5. Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001).

GEN-3102 Functional English Credit Hors. 3(3-0)

Course Objectives:

This course aims to develop students' communicative competence in English as a second or foreign language. It covers the functional aspects of grammar, vocabulary, pronunciation, and discourse in various contexts and situations. It also fosters the skills of reading, writing, listening, and speaking for academic and professional purposes.

Course Contents:

1. Unit 1: Introduction to Functional English
    a. What is functional English, and why is it important?
    b. The four language skills: reading, writing, listening, and speaking
    c. The communicative approach to language teaching and learning
    d. Language functions and notions
    e. Language varieties and registers
2. Unit 2: Functional Grammar

a. Parts of speech and word classes
b. Sentence structure and types
c. Verb tenses and aspects
d. Modality and mood
e. Voice and agency
f. Cohesion and coherence
g. Punctuation and capitalization

3. Unit 3: Functional Vocabulary
    a. Word formation and morphology
    b. Word meaning and semantics
    c. Word collocation and idioms
    d. Word families and synonyms
    e. Word usage and context clues
    f. Word learning strategies and techniques
4. Unit 4: Functional Pronunciation
    a. The sounds of English: vowels, consonants, and diphthongs
    b. Syllables, stress, and intonation
    c. Connected speech: linking, elision, assimilation, etc.
    d. Pronunciation features of different accents and dialects
    e. Pronunciation problems and solutions for second language learners
5. Unit 5: Functional Discourse
    a. Text types and genres: narrative, descriptive, expository, argumentative, etc.
    b. Text organization and structure: introduction, body, conclusion, etc.
    c. Text features and devices: headings, subheadings, bullet points, tables, graphs, etc.
    d. Text analysis and evaluation: purpose, audience, tone, style, etc.
    e. Text production and revision: planning, drafting, editing, proofreading, etc.
6. Unit 6: Functional Communication
    a. Communication skills: listening, speaking, reading, writing
    b. Communication strategies: clarifying, confirming, paraphrasing, summarizing, etc.
    c. Communication contexts: academic, professional, social, etc.

d. Communication situations: formal vs informal; spoken vs written; face-to-face vs online; etc.

e. Communication challenges: intercultural communication, cross-cultural communication, etc.

Recommended Books:

1. Lock, G. (1995). Functional English Grammar: An Introduction for Second Language Teachers. Cambridge University Press.
2. Yule, G. (2010). The Study of Language. Cambridge University Press.
3. Carter, R., & McCarthy, M. (2006). Cambridge Grammar of English. Cambridge University Press.
4. McCarthy M., & O'Dell F. (2008). Academic Vocabulary in Use. Cambridge University Press.
5. Hewings M., & Goldstein N. (2014). Advanced Grammar in Use. Cambridge University Press.
6. Hancock M., & McDonald A. (2013). English Pronunciation in Use Intermediate. Cambridge University Press.
7. Oshima A., & Hogue A. (2006). Writing Academic English. Pearson Longman.
8. Richards J.C., & Schmidt R.W. (2010). Longman Dictionary of Language Teaching & Applied Linguistics. Pearson Education Limited.

GEN-3103 Environmental Science Credit Hrs. 3(2-1)

Course Objectives

- To understand and provide updated knowledge of environmental problems
- To provide a basic introduction to sustainable environmental management.
- To learn a basic introduction about different types of pollution and their adverse effects on the environment**.**

Course Contents

1. **The human environment:** The litho, bio, and hydro spheres, the nature and composition of natural waters,
2. **Pollution:** definition, classification, and impact on habitats
   1. Air pollution**:** Sources and effects of various pollutants (inorganic, organic), control, and remediation. Photochemical smog, Smog, Acid rain: 1. Theory of acid rain, 2. Adverse effects of acid rains. Chlorofluorocarbons and its effects.
   2. Water pollution: Major sources of water pollution and its impact. Prevention, control remediation, Heavy metal pollution. Tanneries. Hospital waste, Treatments of sewage, sludge, and polluted waters.
   3. Soil pollution: major sources of soil pollution and its impact. Prevention, control remediation.
   4. Noise pollution. Sources of Noise pollution, remedies of noise pollution

3. **Ozone layer:**
   i. Formation
   ii. Mechanism of depletion
   iii. Effects of ozone depletion
4. **Greenhouse effect:** causes, impacts.

Practical:

Examination of water for:

i. Total dissolved solids.
ii. pH and Conductance.
iii. Alkalanity.
iv. Hardness of water
v. Determination of phosphates and sulphates

Recommended Books:

1. Newman, E.I. 2001. Applied Ecology.Blackwell Science. UK
2. Mooney, H.A. and Saugier, B. 2000. Terrestrial Global Productivity.Academic Press, UK.
3. Eugene, E.D. and Smith, B.F. 2000. Environmental Science: A study of interrelationships. McGraw Hill. USA.

MATH-3104 Calculus-I Credit Hrs. 3(3-0)

Course Objectives:

This course introduces fundamental concepts of calculus, focusing on limits, derivatives, and their applications.

Course Contents:

Types of functions (algebraic, trigonometric, logarithmic, exponential, hyperbolic, inverse trigonometric, inverse hyperbolic, implicit), algebra of functions (sum, difference, product, quotient, composition of functions), parametric equations, Limits (An Intuitive Approach), Computing Limits, Limits at Infinity, End Behavior of a Function, Limits (Discussed More Rigorously), Continuity, Continuity of Trigonometric, Exponential, and Inverse Functions, Tangent Lines and Rates of Change, The Derivative Function, Introduction to Techniques of Differentiation, The Product and Quotient Rules, Derivatives of Trigonometric Functions, The Chain Rule, Implicit Differentiation, Derivatives of Logarithmic Functions, Derivatives of Exponential and Inverse Trigonometric Functions, Related Rates, Local Linear Approximation, Differentials, L’Hôpital’s Rule, Indeterminate Forms, Increase, Decrease, and Concavity, Relative Extrema, Absolute Maxima and Minima, Applied Maximum and Minimum Problems, Rolle’s Theorem, Mean-Value Theorem.

Recommended Books:

1. Calculus: Early Transcendental” by Howard Anton, Irl Bivens and Stephen Davis
2. Calculus: Early Transcendental" by James Stewart

3. Calculus Volume 1" by Edwin Herman and Gilbert Strang
4. Thomas, *Calculus*, 11th Edition. Addison Wesley Publishing Company, 2005

MATH-3105 Vector Mechanics and Statics Credits Hrs. 3(3-0)

Course Objectives:

Introduction:

What is Mechanics? Fundamental Concepts and Principles, Systems of Units, Conversion from one System of units to another, Method of Problem Solution, Numerical Accuracy.

Statics of Particles:

Introduction, Forces in a Plane, Force on a Particle, Resultant of Two Forces, Vectors, Addition of Vectors, Resultant of Several Concurrent Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors, Addition of Forces by Summing x and y Components, Equilibrium of a Particle, Newton's First Law of Motion, Problems Involving the Equilibrium of a Particle, Free-Body Diagrams, Forces in Space, Rectangular Components of a Force in Space, Force Defined by Its Magnitude and Two Points on Its Line of Action, Addition of Concurrent Forces in Space, Equilibrium of a Particle in Space.

Rigid Bodies: Equivalent Systems of Forces:

Introduction, External and Internal Forces, Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Vector Products Expressed in Terms of Rectangular Components, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about a Given Axis, Moment of a Couple, Equivalent Couples, Addition of Couples, Couples Can Be Represented by Vectors, Resolution of a Given Force into a Force at O and a Couple, Reduction of a System of Forces to One Force and One Couple, Equivalent Systems of Forces, Equipollent Systems of Vectors, Further Reduction of a System of Forces, Reduction of a System of Forces to a Wrench.

Equilibrium of Rigid Bodies:

Introduction, Free-Body Diagram, Equilibrium in Two Dimensions, Reactions at Supports and Connections for a Two-Dimensional Structure, Equilibrium of a Rigid Body in Two Dimensions, Statically Indeterminate Reactions. Partial Constraints, Equilibrium of a Two-Force Body, Equilibrium of a Three-Force Body, Equilibrium in Three Dimensions, Equilibrium of a Rigid Body in Three Dimensions.

Recommended Books

1. F. P. Beer, E. R. Johnston, D. F. Mazurek, P. J. Cornwell, Vector Mechanics for Engineers: Statics and Dynamics, 10^{th} Edition, McGraw-Hill, New York, (2013).

PHY-3106 Mechanics and Theory of Relativity Credit Hrs. 3(3-0)

Course Objectives:

6. To give the concept of vectors and their various properties.
7. To give a basic understanding of laws of motion and their applications in daily life.

8. To give mathematical concepts and expressions of various physical parameters used in mechanics.

<u>Course Contents:</u>

Vector Analysis:

Review of Vector in 3 dimensions and fundamental Operations, Direction, Cosines, Spherical polar coordinates, Cylindrical Coordinates, Vector and scalar triple products, the gradient of a scalar, Divergence and curl of a vector, Physical significance of each type, Divergence of a vector, flux, curl, and line integral (mutual relation). Vector identities, Divergence Theorem, Stokes's Theorem, their derivation, physical importance, and applications to specific cases.

Particle Dynamics:

Dynamics of uniform, circular motion, the banked curve, Equations of motion, Deriving kinetic equations for x(t), v(t) via integration, Constant and variable forces, normal forces and contact forces, special examples, Time-dependent forces, Obtaining x(t), v(t) for this case using integration method, Effect of drag forces on motion, Applying Newton's Laws to obtain v(t) for the case of motion with time-dependent (Integration approach) drag (viscous) forces, terminal velocity, Projectile motion with and without air resistance, Non-inertial frames and Pseudo forces, Qualitative discussion to develop understanding, Calculation of pseudo forces for simple cases (linearly accelerated reference frames), Centrifugal force as an example of pseudo force, Coriolis force.

Work, Power, and Energy:

Work done by a constant force, work done by a variable force (1-2 dimension), (Essentially a review of grade-XII concepts via integration technique to calculate work done (e.g. in a vibration of a spring obeying Hooke's Law), Obtaining general expression for work done (2-dimensional case) and applying to simple cases e.g. pulling a mass at the end of a fixed string against gravity, Work energy theorem, General proof of work energy theorem: Qualitative review of work energy theorem, Derivation using integral calculus, Basic formulae and applications, Power, Energy changes with respect to observers in different inertial frames, Conservation of Energy in 1, 2, and 3 dimensional conservative systems, Conservative and non-conservative forces: Conservation of energy in a system of particles, Law of conservation of total energy of an isolated system.

Special Theory of Relativity:

Inertial and non-inertial frame, Postulates of Relativity, The Lorentz Transformation, Derivation, Assumptions on which inverse transformation is derived, Consequences of Lorentz transformation, Relativity of time, Relativity of length, Relativity of mass, Transformation of velocity, variation of mass with velocity, mass-energy relation, and its importance, relativistic momentum and Relativistic energy, (Lorentz invariants)

Collisions:

Elastic Collisions, Conservation of momentum during a collision in one and two dimensions, Inelastic collision, Collisions in center of Mass reference frame (One and two dimensions), Simple applications, Obtaining velocities in C.M. frame.

Recommended Books:

1. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5th ed. 1999.
2. D. Kleppner and R. Kolenkow, An Introduction to Mechanics, McGraw Hill, 1978.
3. M. R. Speigel, Vector Analysis and an Introduction to Tensor Analysis, Mc-Graw Hill, 1959

PHY-3107 Physics Lab-I Credit Hrs. 1(0-1)

Course Objectives

To develop the experimental capability of students in understanding the concept of Mechanics.

List of Experiments:

1. To determine the value of ‘g’ be compound pendulum (Kater’s Pendulum).
2. To determine Vertical distance by Sextant Apparatus.
3. To determine the modulus of rigidity by Maxwell’s needles and Barton’s Apparatus.
4. To determine the surface tension of water by capillary flow method.
5. To determine the elastic constant, i.e. Modulus of rigidity of a wire by spiral spring.
6. To study the damping features of an oscillating system using a simple pendulum of variable mass.
7. Measurement of viscosity of liquid by Stoke’s / Poiseulli’s method.
8. Determination of the moment of inertia of a solid/hollow cylinder and a sphere, etc.
9. To study the conservation of energy (Hook’s law).
10. To study the dependence of Centripetal force on the mass, radius, and angular velocity of a body in a circular motion.

Recommended Books:

1. D. H. Marrow, Selected Experiments in Physical Sciences, Longman.
2. Nelkon and Ogborn, Advanced Level Practical Physics, Heimann Educational Books
3. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
4. C. K. Bhattacharya, University Practical Physics, CBS Publishing.

Semester-II

GEN-3201 Arabic/ History of Kashmir/History of Islam Credit Hrs. 2(2-0)

Course Objectives:

Familiarize students with the life of the Prophet (SAW), events including wars, pacts, migrations, and the era of Khulafa-i-Rashida

Course outlines

1. **Condition of the world with particular reference to Arabs before the Advent of Isl**
   a. Condition of the world in General with particular reference to Byzentum, Persia, South Asia
   b. Conditions of Pre-Islamic Arabia viz. Religious, Social, Economic, and Political

2. **Life of Rasulullah (SAW)**
   a. Life of Rasulullah (SAW) up to the declaration of Nubuwwat.
   b. His Daawat
   c. Sacrifices of early converts to Islam
   d. Hijrat-i-Habsha
   e. Shiaab-i-Abi Talib

f. Miraj
g. Journey to Taif
h. Ba'at-i-Aqba
i. Hijrat-e-Madina, Muwakhat
j. Meethaqi Madina (Pact)
k. Brief History of the main Ghazwat,
l. Importance of Treaty of Hudabiya
m. Conquest of Makkattul-Mukarrama
n. Hajjat-ul-Widda and Khutbatul Widaa

3. **Teaching of the Rasulullah (SAW)**

The teaching of the Holy Prophet (peace be upon him) as:

a. Social Reformer, Head of the State
b. Supreme Commander, Chief Justice
c. Statesman and Administrator, Educator
d. Upholder of the dignity of labor and a perfect man

4. **Khulafa-i-Rashida**

A brief biographical description of the Khulafa-i-Rashida

a. Hazrat Abu Bakr Siddiq
b. Hazrat Umar Farooq
c. Hazrat Usman Ghani
d, Hazrat Ali-al-Murtaza and Hazrat Hassan

5. **Achievements of Khulafa-i-Rashida**

a. Contribution towards the cause of Islam.
b. Expansion of Islamic State (Hazrat Saad Ibni Abi Waqas, Hazrat Khlid bin Walid. Hazrat Abu Ubaida, Ibnul Jarrah. Hazrat Umar Ibnul Aas, Hazrat Abu Musa Ashari), Administration and judiciary

Recommended Books

1. Tareekh-e-Islam Masood Hyder Bukhari Standard Book House, Lahore.
2. A Study of Islamic History K. Ali Publisher Emporium, Lahore

GEN-3202 Quantitative Reasoning-I Credit Hrs. 3(3-0)

Course Objectives:

Introduction, understanding of the basic mathematical and statistical tools, and real-life applications of quantitative reasoning.

Course Outlines:

Numerical Literacy: Number system and basic arithmetic operations; Units and their conversions, dimensions, area, perimeter and volume; Rates, ratios, proportions and percentages; Types and sources of data; Measurement scales; Tabular and graphical presentation of data; Quantitative reasoning exercises using number knowledge. **Fundamental**

Mathematical Concepts: Basics of geometry (lines, angles, circles, polygons etc.); Sets and their operations; Relations, functions, and their graphs; Exponents, factoring and simplifying algebraic expressions; Algebraic and graphical solutions of linear and quadratic equations and inequalities; Quantitative reasoning exercises using fundamental mathematical concepts. **Fundamental Statistical Concepts:** Population and sample; Measures of central tendency, dispersion and data interpretation; Rules of counting (multiplicative, permutation and combination); Basic probability theory; Introduction to random variables and their probability distributions; Quantitative reasoning exercises using fundamental statistical concepts.

Recommended Books:

1. Quantitative Reasoning: Tools for Today's Informed Citizen by Bernard L. Madison, Lynn and Arthur Steen.
2. Quantitative Reasoning for the Information Age by Bernard L. Madison and David M. Bressoud.
3. Fundamentals of Mathematics by Wade Ellis.
4. Quantitative Reasoning: Thinking in Numbers by Eric Zaslow.
5. Thinking Clearly with Data: A Guide to Quantitative Reasoning and Analysis by Ethan Bueno de Mesquita and Anthony Fowler.
6. Using and Understanding Mathematics: A Quantitative Reasoning Approach by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
7. Discrete Mathematics and its Applications by Kenneth H. Rosen.
8. Statistics for Technology: A Course in Applied Statistics by Chatfield, C.
9. Statistics: Unlocking the Power of Data by Robin H. Lock, Patti Frazer Lock, Kari Lock Morgan, and Eric F. Lock.

GEN-3203 Expository Writing Credit Hrs. 3(3-0)

Course Objectives:

This course is designed to enhance students' expository writing skills, focusing on clear and effective communication of ideas, information, and arguments. Through a series of writing assignments and workshops, students will learn to analyze, synthesize, and present information logically and persuasively.

Course Contents:

Module 1: Introduction to Expository Writing

Understanding expository writing and its significance

Exploring different types of expository writing (informative, analytical, argumentative)

Identifying the target audience and purpose of expository writing

Module 2: Crafting Strong Thesis Statements

Defining a thesis statement and its role in expository writing

Techniques for formulating clear and concise thesis statements

Thesis-driven vs. topic-driven writing

Module 3: Organizing Ideas and Structure

The importance of logical organization in expository writing

Using outlines to plan essays effectively

Introduction, body paragraphs, and conclusion structure

Module 4: Developing Supporting Arguments

Identifying key arguments and points

Building strong and relevant supporting arguments

Avoiding common fallacies in expository writing

Module 5: Incorporating Evidence and Sources

Evaluating credible sources for research

Properly integrating quotations, paraphrases, and summaries

Using citation styles (e.g., APA, MLA) correctly

Module 6: Writing Effective Introductions and Conclusions

Techniques for engaging readers in the introduction

Strategies for concluding essays with impact

Writing hooks, summaries, and clinchers

Module 7: Revising and Editing

The importance of the revision process in expository writing

Self-editing and peer-review techniques

Improving clarity, coherence, grammar, and style

Module 8: Adapting Writing for Different Audiences and Purposes

Tailoring writing for academic, professional, and general audiences

Adapting tone, style, and content to suit the purpose

Module 9: Incorporating Visuals and Multimedia

Effective use of visuals, charts, and graphs in expository writing

Guidelines for integrating multimedia elements

Module 10: Final Projects and Presentation

Students complete a final expository essay on a chosen topic

Presentation of essays and peer feedback

Recommended Books:

1. "They Say / I Say: The Moves That Matter in Academic Writing" by Gerald Graff and Cathy Birkenstein
2. "Writing Analytically" by David Rosenwasser and Jill Stephen
3. "The Elements of Style" by William Strunk Jr. and E.B. White
4. "Bird by Bird: Some Instructions on Writing and Life" by Anne Lamott
5. "Style: Lessons in Clarity and Grace" by Joseph M. Williams and Joseph Bizup
6. "Writing Tools: 50 Essential Strategies for Every Writer" by Roy Peter Clark

MATH-3204 Calculus-II Credit Hrs. 3(3-0)

Course Objective:

This course extends the study of calculus to multivariable functions, including partial differentiation, multiple integration, and vector calculus.

Course Contents:

An Overview of the Area Problem, The Indefinite Integral, Integration by Substitution, The Definition of Area as a Limit, Sigma Notation, The Definite Integral, The Fundamental Theorem of Calculus, Rectilinear Motion Revisited Using Integration, Average Value of a Function and its Applications, Evaluating Definite Integrals by Substitution, Logarithmic and Other Functions Defined by Integrals, Area Between Two Curves, Length of a Plane Curve, Area of a Surface of Revolution, An Overview of Integration Methods, Integration by Parts, Integrating Trigonometric Functions, Trigonometric Substitutions, Integrating Rational Functions by Partial Fractions.

Recommended books:

1. Calculus: Early Transcendentals" by Howard Anton, Irl Bivens and Stephen Davis
2. Calculus: Concepts and Contexts" by James Stewart
3. Calculus Volume 2" by Edwin Herman and Gilbert Strang

MATH-3205 Introduction to Linear Algebra Credit Hr. 3(3-0)

Course Objective:

Basic understanding of matrices, vector space, and linear transformations.

Course Contents:

Vectors and Linear Combinations, Lengths and Dot Products, Matrices, Vectors and Linear Equations, The Idea of Elimination, Elimination Using Matrices, Rules for Matrix Operations, Inverse Matrices, Elimination, Transposes and Permutations, Spaces of

Vectors, The Null space, The Rank and the Row Reduced Form, The Complete Solution to $Ax = b$, Independence, Basis and Dimension, Dimensions of the Subspaces, Orthogonality of the Subspaces, Projections, Orthogonal Bases and Gram-Schmidt, The Properties of Determinants, Permutations and Cofactors, Cramer's Rule, Inverses, and Volumes, Introduction to Eigenvalues, Diagonalizing a Matrix, Symmetric Matrices, Positive Definite Matrices, Similar Matrices, Singular Value Decomposition, The Idea of a Linear Transformation, The Matrix of a Linear Transformation.

Recommended Books:

1. Introduction to Linear Algebra" by Gilbert Strang, 5th Edition
2. Linear Algebra for Everyone" by Gilbert Strang, September 2020
3. Linear Algebra and Learning from Data" by Gilbert Strang, 2019

PHY-3206 Electricity and Magnetism Credit Hrs. 3(3-0)

Course Objectives

1. To give the concept of the electric field, electrical potential, and dielectrics
2. To understand the DC circuits
3. To know the effect of magnetic field and basic magnetic properties of materials

Course Contents:

Electric Field:

Coulomb's law, Field due to a point charge: due to several point charges. Electric dipole. Electric field of continuous charge distribution e.g. Ring of charge, disc of charge, an infinite line of charge. Point charge in an electric field. Dipole in an electric field, Torque and energy of a dipole in a uniform field. Electric flux: Gauss's law; (Integral and differential forms) and its application. Charge in isolated conductors, conductor with a cavity, field near a charged conducting

Electric Potential:

Potential due to point charge, potential due to collection of point charges, potential due to dipole. The electric potential of continuous charge distribution. Field as the gradient or derivative of potential. Potential and field inside and outside an isolated conductor.

Capacitors and dielectrics:

Capacitance, calculating the electric field in acapacitor. Capacitors of various shapes, cylindrical, spherical etc. and calculation of their capacitance. Energy stored in an electric field. Energy per unit volume. Capacitor with Dietetic, Electric field of dielectric. An atomic view. Application of Gauss's Law to capacitor with dielectric.

Magnetic Field Effects and Magnetic Properties of Matter:

Magnetic force on a charged particle, magnetic force on a current, Recall the previous results. Do not derive. Torque on a current loop. Magnetic dipole: Energy of magnetic dipole in the field, Lorentz Force, Biot-Savart Law: Analytical treatment and applications to a current loop, force on two parallel current changing conductors. Ampere's Law, Integral and differential forms, applications to solenoids and toroids. (Integral form).

Inductance:

Faraday's Law of Electromagnetic Induction, Review of emf, Faraday Law and Lenz's Law, Induced electric fields, Calculation and application using differential and integral form, Inductance, "Basic definition". Inductance of a Solenoid; Toroid.

Alternating Current Circuits:

Alternating current, AC current in resistive, inductive, and capacitative elements. Single loop RLC circuit, Series and parallel circuits, Analytical expression for time-dependent solution. Graphical analysis, phase angles, Power in A.C circuits: phase angles, RMS values, power factor.

Recommended Books:

1. F. J. Keller, W. E. Gettys, M. J. Skove *Physics Classical and Modern (2nd edition)*, McGraw-Hill, Inc., 1993.
2. A. F. Kip Fundamentals of Electricity and Magnetism (2nd Ed.), McGraw-Hill Book Co., 1969.
3. D. Halliday, R. Resnick, K. S. Krane Physics (Vol-II), John Willey & Sons, Inc., 1992.
4. D. N. Vasudeva Magnetism and Electricity, S. Chand & Co., 1959.
5. J. A. Edminister Schaum's Outline Series; Theory and Problems of Electromagnetism, McGraw-Hill Book Co., 1986.

PHY-3207 Physics Lab-II Credit Hrs. 1(0-1)

Course Objectives

To develop the understanding of students in measuring the thermal and optical parameters and to remove the fear of students using various gadgets in the laboratory.

List of experiments:

1. To determine the frequency of A.C supply by Melde's experiment.
2. To determine the frequency of A.C. supply by electric sonometer
3. To study the combinations of harmonic motion (Lissajous figures).
4. To study the parameters of waves (Beats phenomenon).
5. To determine the frequency of AC supply by CRO
6. The determination of the wavelength of Sodium -D lines by Newton's Ring.
7. Determination of wavelength of sodium light by Fresnel's bi-prism.
8. The determination of the resolving power of a diffraction grating.
9. Study of the parameter of wave i.e. amplitude, phase, and time period of a complex signal by CRO.
10. Specific rotation of cane-sugar solution with Laurent's half-shade polarimeter

Recommended Books:

1. D. H. Marrow, Selected Experiments in Physical Sciences, Longman.
2. Nelkon and Ogborn, Advanced Level Practical Physics, Heimann Educational Books
3. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.

4. C. K. Bhattacharya, University Practical Physics, CBS Publishing

Semester-III

GEN-4301: Applications of Information and Communication Technologies

Credit Hrs. 3 (2-1)

Course Objectives:

This course explores the practical applications of Information and Communication Technologies (ICT) across various sectors. It introduces students to tools, software, and technologies that are widely used in today's digital world. Through theoretical knowledge and hands-on experience, students will learn how ICT plays a crucial role in modern business, education, healthcare, and society.

Course Contents:

Module 1: Introduction to Information and Communication Technologies

- Definition, scope, and significance of ICT
- Evolution of ICT and its impact on society
- Ethical and privacy considerations in the digital age

Module 2: Computer Applications and Software Tools

- Introduction to productivity software (word processing, spreadsheets, presentations)
- Database management systems and data analysis tools
- Graphics and multimedia software for content creation

Module 3: Internet and Communication Technologies

- Web browsing and search engines
- Email communication and netiquette
- Social media platforms and online collaboration tools

Module 4: E-Commerce and Online Transactions

1. Introduction to electronic commerce
2. Online payment systems and security
3. E-commerce platforms and digital marketing

Module 5: Educational Applications of ICT

- E-learning platforms and online education tools
- Virtual classrooms and educational resources
- Gamification and interactive learning experiences

Module 6: Health Informatics

- Electronic health records and patient management systems
- Telemedicine and remote health monitoring
- Health-related mobile apps and wearables

Module 7: Business and Enterprise Solutions

- Enterprise resource planning (ERP) systems
- Customer relationship management (CRM) software
- Supply chain management and business analytics

Module 8: Smart Cities and IoT Applications

- Concepts of smart cities and urban technology

- Internet of Things (IoT) and sensor networks
- Case studies of IoT applications in urban infrastructure

Module 9: Data Security and Privacy

- Basics of cybersecurity and encryption
- Privacy concerns in the digital world
- Protecting personal and sensitive information

Module 10: Future Trends and Innovations in ICT

- Emerging technologies (AI, blockchain, quantum computing)
- The role of ICT in sustainability and global challenges
- Ethical considerations in the adoption of new technologies

Recommended Books:

1. Introduction to Information Systems" by R. Kelly Rainer Jr., Brad Prince, and Casey G. Cegielski
2. Information Technology for Management: Digital Strategies for Insight, Action, and Sustainable Performance" by Efraim Turban, Linda Volonino, and Gregory R. Wood
3. Digital Transformation: Survive and Thrive in an Era of Mass Extinction" by Thomas M. Siebel
4. E-Commerce 2022" by Kenneth C. Laudon and Carol Guercio Traver
5. Digital Health: Scaling Healthcare to the World" by Mohit Joshi and Rishi Bhatnagar

<u>Practical Work for "GEN-4301":</u>

Lab Session 1: Productivity Software

- Introduction to word processing software (Microsoft Word, Google Docs)
- Creating and formatting documents
- Practical exercise: Designing a professional document

Lab Session 2: Spreadsheet and Data Analysis

- Working with spreadsheet software (Microsoft Excel, Google Sheets)
- Data entry, manipulation, and basic formulas
- Practical exercise: Creating a budget or financial analysis

Lab Session 3: Presentation Tools

- Creating effective presentations using software (Microsoft PowerPoint, Google Slides)
- Designing slides, adding multimedia, and transitions
- Practical exercise: Delivering a persuasive presentation

Lab Session 4: Internet and Online Communication

- Web browsing, search engines, and online research
- Email communication and etiquette
- Practical exercise: Exploring online resources and sending professional emails

Lab Session 5: Social Media and Online Collaboration

- Exploring social media platforms (Facebook, LinkedIn, Twitter)
- Collaborative tools for online teamwork (Google Drive, Microsoft Teams)
- Practical exercise: Creating a collaborative document and sharing it online

Lab Session 6: E-Commerce Simulation

- Simulating an e-commerce transaction using a platform (e.g., Shopify)
- Understanding the steps involved in online purchasing
- Practical exercise: Setting up a basic online store

Lab Session 7: Educational Technology Tools

- Exploring e-learning platforms (Moodle, Canvas)
- Creating and managing online courses
- Practical exercise: Designing a mini online course module

Lab Session 8: Health Informatics Simulation

- Using health-related mobile apps for monitoring (e.g., fitness trackers)
- Simulating health data collection and analysis
- Practical exercise: Tracking health parameters using a mobile app

Lab Session 9: Business Software and Enterprise Solutions

- Introduction to business software (ERP, CRM)
- Simulating enterprise resource planning processes
- Practical exercise: Managing customer relationships in a CRM system

Lab Session 10: IoT and Smart Devices

- Exploring the Internet of Things (IoT) devices and sensors
- Setting up and collecting data from IoT devices
- Practical exercise: Monitoring environmental parameters using IoT sensors

GEN-4302 Quantitative Reasoning-II Credit Hrs. 3(3-0)

Course Objectives:

Summarizing, interpreting, and presenting quantitative data in mathematical forms, such as graphs, charts, tables, or mathematical text. Construct or compute representations of data using mathematical forms or equations as models and use statistical methods to assess their accuracy.

Course Contents:

Logic, Logical and Critical Reasoning: Introduction and importance of logic; Inductive, deductive and abductive approaches of reasoning; Propositions, arguments (valid; invalid), logical connectives, truth tables and propositional equivalences; Logical fallacies; Venn Diagrams; Predicates and quantifiers; Quantitative reasoning exercises using logical reasoning concepts and techniques. **Mathematical Modeling and Analyses:** Introduction to deterministic models; Use of linear functions for modeling in real-world situations; Modeling with the system of linear equations and their solutions; Elementary introduction to derivatives in mathematical modeling; Linear and exponential growth and decay models; Quantitative reasoning exercises using mathematical modeling. **Statistical Modeling and Analyses**: Introduction to probabilistic models; Bivariate analysis, scatter plots; Simple linear regression model and correlation analysis; Basics of estimation and confidence interval; Testing of hypothesis (z-test; t-test); Statistical inference in decision making; Quantitative reasoning exercises using statistical modeling.

Recommended Books:

1. Using and Understanding Mathematics: A Quantitative Reasoning Approach by Bennett, J. O., Briggs, W. L., & Badalamenti, A.
2. Discrete Mathematics and its Applications byy Kenneth H. Rosen.
3. Discrete Mathematics with Applications by Susanna S. Epp.
4. Applied Mathematics for Business, Economics and Social Sciences by Frank S. Budnick.
5. Elementary Statistics: A Step-by-Step Approach by Allan Bluman.
6. Introductory Statistics by Prem S. Mann.
7. Applied Statistical Modeling by Salvatore Babones.
8. Barrons SAT by Sharvon Weiner Green, M.A and Ira K. Wolf.

GEN-4303 Civics and Community Engagement 2 (2-0)

Course Objectives:

This course explores the fundamental concepts of civics, citizenship, and community engagement. It emphasizes the role of active participation, civic responsibility, and ethical engagement in building a just and equitable society. Through theoretical knowledge and practical exercises, students will learn how to become informed and engaged citizens who contribute positively to their communities.

Course Contents:

Module 1: Introduction to Civics and Citizenship

- Definition and importance of civics education
- Roles and responsibilities of citizens in a democracy
- Historical evolution of citizenship concepts

Module 2: Democratic Governance and Political Participation

- Types of democracies and principles of democratic governance
- Electoral systems and political parties
- Voter education and political participation

Module 3: The Constitution and Rule of Law

- Basics of constitutional law and its significance
- Separation of powers and checks and balances

- Protecting individual rights and civil liberties

Module 4: Public Policy and Civic Engagement

- Understanding public policy and its impact
- Role of advocacy and lobbying in shaping policies
- Civic engagement strategies for policy change

Module 5: Civil Society and Non-Governmental Organizations (NGOs)

- Defining civil society and its functions
- Role of NGOs in promoting social justice and development
- Collaborations between NGOs, governments, and businesses

Module 6: Media Literacy and Civic Education

- Importance of media literacy in an information-driven society
- Analyzing media bias and misinformation
- Utilizing media for civic education and awareness

Module 7: Social Justice and Human Rights

- Concepts of social justice and equity
- Promoting human rights and addressing discrimination
- Intersectionality and the impact of multiple identities

Module 8: Community Engagement and Service Learning

- Principles of community engagement and service learning
- Collaborative problem-solving and community needs assessment
- Implementing sustainable community development projects

Module 9: Ethical Leadership and Decision-Making

- Characteristics of ethical leaders
- Ethical decision-making frameworks
- Applying ethics to community engagement and activism

Module 10: Global Citizenship and Sustainability

- Understanding global citizenship and interconnectedness
- Addressing global challenges (climate change, poverty)
- Sustainable development and responsible global citizenship

Recommended Books:

1. Civics Today: Citizenship, Economics, & You" by McGraw-Hill Education
2. Civic Engagement in American Democracy" by David J. Houston and Mark Carl Rom
3. The Civic Web: Young People, the Internet, and Civic Participation" by Shakuntala Banaji

4. Becoming a Citizen Activist: Stories, Strategies, and Advice for Changing Our World" by Nick Licata
5. Citizens, Politics, and Social Communication: Information and Influence in an Election Campaign" by Dietram A. Scheufele.

MATH-4304 Calculus-III Credit Hrs. 3(3-0)

Course Objectives:

This course extends the study of infinite series, conic sections, and calculus to multivariable functions, including partial differentiation, multiple integration, and vector calculus.

Course Contents:

Sequences, Monotone Sequences, Infinite Series, Convergence Tests, The Comparison, Ratio, and Root Tests, Alternating Series, Absolute and Conditional Convergence, Maclaurin and Taylor Polynomials, Maclaurin and Taylor Series; Power Series, Convergence of Taylor Series, Differentiating and Integrating Power Series, Modeling with Taylor Series, Parametric Equations, Tangent Lines and Arc Length for Parametric Curves, Polar Coordinates, Tangent Lines, Arc Length, and Area for Polar Curves, Conic Sections, Rotation of Axes, Second-Degree Equations, Conic Sections in Polar Coordinates, Rectangular Coordinates in 3-Space, Spheres, Cylindrical Surfaces, Parametric Equations of Lines, Planes in 3-Space, Quadric Surfaces, Functions of Two or More Variables, Limits and Continuity, Partial Derivatives, Differentiability, Differentials, and Local Linearity, The Chain Rule, Directional Derivatives and Gradients, Tangent Planes and Normal Vectors, Maxima and Minima of Functions of Two Variables, Lagrange Multipliers, Cylindrical and Spherical Coordinates, Double Integrals, Double Integrals over Nonrectangular Regions, Double Integrals in Polar Coordinates, Surface Area, Parametric Surfaces, Triple Integrals, Change of Variables in Multiple Integrals, Jacobians.

Recommended books:

1. Multivariable Calculus" by James Stewart
2. Calculus Volume 3" by Edwin Herman and Gilbert Strang
3. Calculus: Early Transcendental" by Howard Anton, Irl Bivens and Stephen Davis

MATH-4305 Numerical Analysis-I Credit Hrs. 3(3-0)

Course Objectives:

This course introduces students to fundamental numerical methods for solving mathematical problems and approximating solutions to mathematical equations and functions.

Course Contents:

Introduction to Numerical Analysis: Overview of numerical methods and their significance, Sources of error in numerical computations, Root Finding and Nonlinear Equations**:** Bisection method**,** False position method**,** Newton-Raphson method**,** Secant method**,** Fixed point iteration method**,** Convergence and stopping criteria**,** Interpolation and Polynomial Approximation: Lagrange interpolation**,** Newton's divided-difference interpolation**,** Hermit interpolation**,** Polynomial interpolation error**,** Numerical Differentiation, and Integration: Forward, backward, and central difference approximations**,** Numerical integration: trapezoidal rule, Simpson's rule**,** Error analysis for differentiation and integration**,** Systems of Linear Equations: Gaussian elimination methods**,** Gauss Jordan method, matrix inversion, LU decomposition**,** Iterative methods: Jacobi, Gauss-Seidel, SOR.

Recommended books:

1. Numerical Analysis" by Richard L. Burden and J. Douglas Faires
2. An Introduction to Numerical Analysis" by Endre Süli and David F. Mayers
3. Introduction to Numerical Analysis" by J. Stoer and R. Bulirsch
4. Numerical Methods for Scientists and Engineers" by R.W. Hamming

PHY-4306 Waves, Oscillations, and Thermodynamics Hrs. 3(3-0)

Course Objective:

1. To understand the basics of waves, the mechanism of wave production, propagation and interaction with other waves.
2. Use of the basic concept of waves in their application in daily life.

Course Contents:

Harmonic Oscillations:

Simple harmonic motion (SHM), Obtaining and solving the basic equations of motion x (t), v (t), a (t), Longitudinal and transverse Oscillations, and Energy considerations in SHM. Application of SHM, Torsional oscillator, Physical pendulum, simple pendulum, SHM,, and uniform circular motion, Combinations of harmonic motions, Lissajous patterns, Damped harmonic motion, Equation of damped harmonic motion, Quality factor, discussion of its solution, Forced oscillations and resonances, Equation of forced oscillation, Discussion of its solution, Natural frequency, Resonance, Examples of resonance.

Waves in Physical Media:

Mechanical waves, Travelling waves, Phase velocity of traveling waves, Sinusoidal waves, Group speed and dispersion, Waves speed, Mechanical analysis, Wave equation, Discussion of solution, Power, and intensity in wave motion, Derivation & discussion, Principle of superposition (basic ideas), Interference of waves, Standing waves. Phase changes on reflection, Beats Phenomenon, Analytical treatment, Electromagnetic Spectrum, Doppler Effect Reflection and Refraction of light waves, Total internal reflection, Plane and Spherical Mirrors, Double slit Interference, Michelson and Fabry-Perot Interferometers.

Thermodynamics:

Review of previous concepts. The first law of thermodynamics and its applications to adiabatic, isothermal, cyclic, and free expansion, Reversible and irreversible processes, the Second Law of thermodynamics, Carnot theorem, Carnot engines. Heat engine, Refrigerators, Calculation of efficiency of heat engines. Thermodynamic temperature scale: Absolute zero: Entropy, Entropy in a reversible process, Entropy in an irreversible process. Entropy & second law. Entropy & probability.

Recommended Books:

1. Halliday, D. Resnick, Krane, Physics, Vol. I & II, John Wiley, 5^{th} ed. 1999.
2. N.K. Bajaj, The Physics of Waves & Oscillations, Tata McGraw-Hill Publishing company Limited, 1986.
3. H. J. Pain, The Physics of Vibrations and Waves, 5^{th} Edition 1999.
6. J. A. Edminister Schaum's Outline Series; Theory and Problems of Electromagnetism, McGraw-Hill Book Co., 1986.
7. J. F. Lee and F. W. Sears, Thermodynamics, Addison-Wesley 1954.
8. 2. A. J. Pointon, Introduction to Statistical Physics, Longman 1967.
9. 3. M. W. Zemansky, Heat and Thermodynamics, 3rd Edition, McGraw Hill, 1951.
10. 4. Reif, Statistical Physics, Berkley Physics series, McGraw Hill 1965.
11. 5. M. M. Abbott, Schaum's Outline of Thermodynamics, McGraw-Hill Professional Book Group, 1995.

PHY-4307 Physics Lab-III Credit Hrs. 1(0-1)

Course Objectives:

To know the electrical circuit elements and their experimental measurement to give an understanding of electrical circuits and the use of CRO.

List of Experiments:

1. 1 Calibration of an Ammeter and a Voltmeter by potentiometer
2. Comparison of capacities by ballistic galvanometer.
3. Measurement of self/mutual inductance.
4. To convert a Western-type galvanometer into an ammeter reading up to 1 ampere (0-1amp range)
5. To convert a moving coil (Western type) galvanometer into a voltmeter reading up to 3 volts (0-3Volt range)
6. Setup of a RLC series circuit. Draw its frequency response curve and find the values of resonance frequency bandwidth and quality factor.

7. Setup of a RLC parallel circuit. Draw its frequency response curve and find the values of resonance frequency bandwidth and quality factor.
8. To determine thermal Emf and plot temperature diagram.
9. Calibration of the thermocouple by the potentiometer.
10. To study the network theorems (Superposition, Thevinin, Norton).

Recommended Books:

1. G L Squires, Practical Physics, 3rd Edition, Cambridge University Press
2. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.

Semester-IV

GEN-4401 Fundamental of Sociology Credit Hrs. 2(2-0)

Course Objectives:

This course introduces students to the fundamental concepts, theories, and methods of sociology, exploring how society functions and influences human behavior.

Course Contents:

- Introduction to Sociology
  - Defining sociology and its significance
  - The sociological perspective and imagination
- Foundations of Sociological Thinking
  - Major sociological theories: functionalism, conflict theory, symbolic interactionism
  - Sociological research methods: quantitative and qualitative approaches
- Culture and Socialization
  - Definition of culture and cultural relativism
  - Elements of culture: norms, values, symbols
  - Agents of socialization: family, peers, media
- Social Structure and Institutions
  - Social structure: status, roles, social groups
  - Institutions: family, education, religion, economy, politics
  - Social roles and role conflict
- Social Stratification and Inequality
  - Social classes and socioeconomic inequality

    - Race, ethnicity, and gender as sources of inequality
    - Social mobility and its determinants
- Deviance and Crime
    - Theories of deviance: strain theory, labeling theory, control theory
    - Types of deviant behavior: crime, delinquency
    - Social control and the criminal justice system
- Social Change and Globalization
    - Social change theories: modernization, conflict, globalization
    - Impact of technology, communication, and migration
    - Social movements and their role in change
- Social Institutions and Issues in Society
    - Marriage and family dynamics
    - Education and its functions
    - Religion and its role in society
    - Health and healthcare disparities
- Sociology in Everyday Life
    - Applying sociological concepts to real-life situations
    - Understanding social issues and making informed decisions

Recommended Books:

1. Sociology: A Brief Introduction" by Richard T. Schaefer
2. Sociology: The Essentials" by Margaret L. Andersen and Howard F. Taylor
3. Introduction to Sociology" by Anthony Giddens, Mitchell Duneier, Richard P. Appelbaum, and Deborah Carr
4. The Sociological Imagination" by C. Wright Mills
5. Social Research Methods" by Alan Bryman
6. The Presentation of Self in Everyday Life" by Erving Goffman

GEN-4402: Ideology and Constitution of Pakistan Credit Hrs. 2(2-0)

Course Objectives:

This course provides an overview of the historical, social, political, and cultural aspects of Pakistan, with a focus on its development as a nation and its role in the global context.

Course Contents:

- **Introduction to Pakistan Studies**
    - Objectives and scope of the course
    - Importance of studying Pakistan's history and culture
- **Geography and Natural Resources**
    - Physical and political geography of Pakistan
    - Major rivers, mountains, and regions
    - Natural resources and their significance
- **Historical Background**
    - Ancient civilizations in the region
    - Muslim rule in the Indian subcontinent
    - Events leading to the creation of Pakistan
- **Foundations of Pakistan (1947-1958)**
    - Partition of India and creation of Pakistan
    - Role of leaders like Jinnah and Allama Iqbal
    - Challenges faced by the new nation
- **Pakistan's Political History**
    - Major political developments and changes in leadership
    - Constitution and political system
    - Military coups and democratic transitions
- **Socio-Cultural Dynamics**
    - Ethnic diversity and cultural heritage
    - Languages, arts, and literature of Pakistan
    - Religious diversity and its impact
- **Economic Development and Challenges**
    - Economic sectors: agriculture, industry, and services
    - Major challenges: poverty, unemployment, and inflation
    - Efforts toward economic growth and stability
- **Foreign Relations and Geopolitics**
    - Relations with neighboring countries and major powers
    - Role in regional and international organizations
    - Security challenges and peace efforts

- **Contemporary Issues and Prospects**
  - Terrorism and extremism
  - Social and educational challenges
  - Future prospects and national aspirations
- Books Rec*ommended:*
- *Muhammad Raza Kazmi, Pakistan Studies, Oxford University Press, 2007*
- Akbar, S. Zaidi. Issue in Pakistan's Economy. Karachi: Oxford University Press, 2000.
- Mehmood, Safdar. Pakistan Political Roots & Development. Lahore, 1994.
- Amin, Tahir. Ethno - National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad.
- Zahid, Ansar. History & Culture of Sindh. Karachi: Royal Book Company, 1980.
- Afzal, M. Rafique. Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and Cultural Research, 1998.
- Muhammad Waseem, Pakistan under Martial Law, Lahore: Vanguard, 1987.
- Haq, Noor ul. Making of Pakistan: The Military Perspective. Islamabad: National Commission on Historical and Cultural Research, 1993.
- Amin, Tahir. Ethno - National Movement in Pakistan, Islamabad: Institute of Policy Studies, Islamabad.
- Zahid, Ansar. History & Culture of Sindh. Karachi: Royal Book Company, 1980.
- Afzal, M. Rafique. Political Parties in Pakistan, Vol. I, II & III. Islamabad: National Institute of Historical and Cultural Research, 1998.
- Sayeed, Khalid Bin. The Political System of Pakistan. Boston: Houghton Mifflin, 1967.
- Aziz, K.K. Party, Politics in Pakistan, Islamabad: National Commission on Historical and Cultural Research, 1976.

GEN-4403 Entrepreneurship Credit Hrs. 2 (2-0)

Course Objectives:

This course introduces students to the fundamental concepts of entrepreneurship, focusing on developing an entrepreneurial mindset, recognizing opportunities, and understanding the key components of starting and managing a business. Through theoretical knowledge and practical exercises, students will gain insights into the challenges and strategies involved in becoming successful entrepreneurs.

Course Contents:

Module 1: Introduction to Entrepreneurship

- Definition of entrepreneurship and its significance
- Traits and characteristics of successful entrepreneurs
- Types of entrepreneurship: Small business vs. high-growth startups

Module 2: Entrepreneurial Mindset and Creativity

- Developing an entrepreneurial mindset

- Importance of creativity and innovation in entrepreneurship
- Techniques for fostering creativity and thinking outside the box

Module 3: Identifying Business Opportunities

- Recognizing market gaps and customer needs
- Market research and feasibility analysis
- Evaluating the potential of a business idea

Module 4: Business Planning and Model

- Elements of a comprehensive business plan
- Business model canvas and lean startup approach
- Defining the value proposition and revenue streams

Module 5: Funding and Financial Management

- Sources of funding for startups (angel investors, venture capitalists, crowdfunding)
- Budgeting, financial projections, and managing startup costs
- Financial management and sustainability strategies

Module 6: Marketing and Sales Strategies

- Creating a marketing plan and target audience analysis
- Branding, digital marketing, and social media strategies
- Sales techniques and customer relationship management

Module 7: Legal and Regulatory Aspects

- Legal forms of business (sole proprietorship, partnership, corporation)
- Intellectual property protection and legal considerations
- Compliance with regulations and licensing requirements

Module 8: Operations and Supply Chain Management

1. Managing day-to-day operations and processes
2. Supply chain management and vendor relationships
3. Quality control and efficiency optimization

Module 9: Growth Strategies and Scaling

1. Strategies for business growth and expansion
2. Challenges and opportunities in scaling a startup
3. Internationalization and entering new markets

Module 10: Entrepreneurial Leadership and Ethical Considerations

1. Leadership styles and characteristics of effective entrepreneurial leaders
2. Ethical challenges in entrepreneurship and social responsibility
3. Balancing profit goals with ethical decision-making

Recommended Books:

1. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses" by Eric Ries
2. Entrepreneurship: Successfully Launching New Ventures" by Bruce R. Barringer and R. Duane Ireland
3. Disciplined Entrepreneurship: 24 Steps to a Successful Startup" by Bill Aulet
4. Zero to One: Notes on Startups, or How to Build the Future" by Peter Thiel with Blake Masters
5. The Art of Startup Fundraising: Pitching Investors, Negotiating the Deal, and Everything Else Entrepreneurs Need to Know" by Alejandro Cremades
6. Good to Great: Why Some Companies Make the Leap and Others Don't" by Jim Collins

MATH-4404 Ordinary Differential Equations Credit Hrs. 3(3-0)

Course Objectives:

1. Understand physical systems that can be described by differential equations
2. Understand the practical importance of solving differential equations
3. Understand the differences between initial value and boundary value problems (IVPs and BVPs)
4. Appreciate the importance of establishing the existence and uniqueness of solutions
5. Recognize an appropriate solution method for a given problem
6. Classify differential equations.
7. Real-life applications of differential equations.

Course Contents:

First Order Differential Equations: Linear Equations, Method of Integrating Factors, Separable Equations, Modeling with First Order Equations, Differences between Linear and Nonlinear Equations, Autonomous Equations and Population Dynamics, Exact Equations and Integrating Factors, The Existence and Uniqueness Theorem. Second Order Linear Equations: Homogeneous Equations with Constant Coefficients, Solutions of Linear Homogeneous Equations, The Wronskian, Complex Roots of the Characteristic Equation, Repeated Roots, Reduction of Order, Nonhomogeneous Equations, Method of Undetermined Coefficients, Variation of Parameters. Higher Order Linear Equations: General Theory of nth Order Linear Equations, Homogeneous Equations with Constant Coefficients, The Method of Undetermined Coefficients, The Method of Variation of Parameters. Series Solutions of Second Order Linear Equations: Solutions About Ordinary Points, Solutions About Singular Points, Special Functions, Bessel’s Equation, Legendre’s Equation.

Recommended Books:

1. Elementary Differential Equations and Boundary Value Problems” by William E. Boyce and Richard C. DiPrima
2. Differential Equations with Boundary-Value Problems” by Dennis G. Zill

MATH-4405 Mathematical Computing Credit Hrs. 3(3-0)

Course Objectives:

This course introduces students to mathematical computing using software tools, with a focus on Mathematica. Students will learn how to use computational techniques to solve mathematical problems and visualize mathematical concepts.

Course Contents:

1. **Introduction to Mathematical Computing**
   - Overview of computational tools in mathematics
   - Introduction to Mathematica interface and basic functionalities
2. **Symbolic Manipulation**
   - Performing algebraic manipulations using Mathematica
   - Simplification, expansion, and factorization of expressions
   - Solving equations symbolically
3. **Numerical Methods and Approximations**
   - Numeric evaluation of mathematical expressions
   - Solving equations numerically using iterative methods
   - Approximation techniques: Taylor series, truncation, and rounding errors
4. **Plotting and Visualization**
   - Creating 2D and 3D plots of functions and data
   - Customizing plot appearance and labels
   - Visualizing mathematical concepts and relationships
5. **Calculus with Mathematica**
   - Computing derivatives and integrals symbolically
   - Applications of calculus: optimization, area, and volume
6. **Linear Algebra and Matrix Computations**
   - Manipulating matrices and vectors using Mathematica
   - Solving systems of linear equations
   - Eigenvalues and eigenvectors
7. **Differential Equations**
   - Solving ordinary differential equations (ODEs) symbolically and numerically
   - Systems of ODEs and initial value problems
8. **Programming in Mathematica**

- Introduction to programming concepts in Mathematica
- Defining functions, loops, and conditional statements
- Creating custom computational tools

9. **Mathematica Applications in Various Mathematical Fields**
   - Exploring applications in calculus, linear algebra, discrete mathematics, and more
   - Symbolic and numerical solutions to real-world mathematical problems

Recommended books:

1. A Beginner's Guide to Mathematica" by David McMahon and Daniel M. Topa
2. The Student's Introduction to Mathematica" by Bruce Torrence and Eve A. Torrence
3. Hands-on Start to Wolfram Mathematica and Programming with the Wolfram Language" by Cliff Hastings, Kelvin Mischo, and Michael Morrison

PHY-4406: Modern Physics and Electronics Credit Hrs. 3(3-0)

Course Objectives:

1. To give the concept of modern physics
2. To know the nuclear structure and radioactivity
3. To know some nuclear reactions and the production of nuclear energy
4. To give a basic understanding of Plasma and LASER

Course Contents

Electronics:

Basic crystal structure, free electron model, energy band in solid and energy gaps, p-type, n-type semiconductor materials, p-n junction diode, its structure. Characteristics and application as rectifiers. Transistor, its basic structure and operation, transistor biasing for amplifiers, characteristics of common base, common emitter, common collector, load line, operating point, hybrid parameters (common emitter), Transistor as an amplifier (common emitter mode), Positive & and negative feed-back R.C. Oscillators, Monostable multi-vibrator (basic), Logic gates OR, AND, NOT, NAND, NOR and their basic applications.

Origin of Quantum Theory:

Black body radiation, Stefan Boltzmann, Wien's, and Planck's law, consequences, the quantization of energy, photoelectric and Compton Effect, Line spectra, explanation using quantum theory.

Wave Nature of Matter:

Wave behavior of particle (wave function etc.), its definition and relation to the probability of particle, de Broglie hypothesis and its testing, Davisson-Germer Experiment and J.P. Thomson Experiment, Wave packets, and particles, localizing a wave in space and time.

Atomic Physics:

Bohr's theory (review), Frank-Hertz experiment, energy levels of electrons, Atomic spectrum, Angular momentum of electrons, Vector atom model, Orbital angular momentum. Spin quantization, Bohr's Magnetron. X-ray spectrum (continuous and discrete) Moseley's law, Pauli's exclusion principle, and its use in developing the periodic table.

Recommended Books:

1. Robert M Eisberg, Fundamentals of Modern Physics, John Wiley & Sons 1961
2. Sanjiv Puri, Modern Physics, Narosa Publishing House, 2004.
3. Paul A. Tipler and Ralph A. Llewellyn, Modern Physics 3rd edition, W H Freeman and Company 2000.
4. Arthur Beiser, Concepts of Modern Physics (fifth edition) McGraw-Hill 1995.
5. Robert M. Eisberg and Robert Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2nd edition, John Wiley & Sons, 2002.
6. D. Halliday, R. Resnick, K. S. Krane, *Physics*, John Willey & Sons, Inc.

PHY-4407 Physics Lab-IV Credit Hrs. 1(0-1)

List of Experiments:

1. To develop an understanding and uses of electronic devices, including GATS, Transistors.
2. Determination of ionization potential of mercury.
3. Characteristics of a semiconductor diode (Compare Si with Ge diode)
4. Setting up of half and full wave rectifier & and study of following factors
   i. Smoothing effect of a capacitor
   ii. Ripple factor & its variation with the load.
   iii. Study of regulation of output voltage with load.
5. To set up a single-stage amplifier & and measure its voltage gain and bandwidth.
6. To set up a transistor oscillator circuit and measure its frequency with an oscilloscope.
7. To set up and study various logic gates (AND, OR, NAND, etc.) using diode and to develop their truth table.
8. To set up an electronic switching circuit using transistor LDR and demonstrate its use as a NOT Gate.
9. Characteristics of a transistor.
10. Use of computers in the learning of knowledge of GATE and other experiments.

Recommended Books:

1. G L Squires, Practical Physics, 3rd Edition, Cambridge University Press
2. 2. Nolan and Bigliani, Experiments in Physics, Surjeet Pub Ind.
3. C K Bhattacharya, University Practical Physics, CBS Publishing.

Semester-V

PHY-5501: Lab-V (Electronics) Credit Hrs. 3(3-0)

Course Objectives:

1. To develop the understanding of students in measuring the electronic parameters and to remove the fear of students using various gadgets in the laboratory
2. To develop an understanding and uses of electronic devices, including GATS and transistors.

Course Contents:

1. Transmission Lines, design construction, and characteristics study.
2. Design and construction of RLC series and Parallel and Tuned circuits and characteristics study.
3. Wave shaping circuits (Integrator, Differentiator, Clipper, and Clapper) and Low Pass and High filters design and construction and characteristics study
4. Study of PN-junction diode characteristics and construction of half wave and full wave (center tapped and bridge) circuits and study of their characteristics with load resistance and filters
5. Design of a low tension transistorized regulated power supply and study of its regulation.
6. Draw BJT (Bipolar junction transistor) I/P and O/P characteristics in CE and CB configuration and Derivation of I/P and O/P parameters.
7. Design and construction of a single-stage common emitter transistor amplifier and Derivation of I/P and O/P parameters.
8. Design and construction of an Operational amplifier with 741 IC and study its characteristics and functions
9. Design and construction of RC and Hartley Oscillators and study of their characteristic parameters.
10. Design and construction of discrete AND, OR, NOT (invertor), NAND, and NOR Logic Gate circuits and verify their truth tables and use of 7400 and 7403 ICs for the same purposes.
11. Design and construction of monostable, astable, and bistable multivibrators and flip-flops and study their characteristics
12. Design and construction of multivibrators using 555 timer IC and study their characteristics.

PHY-5502: Classical Mechanics Credit Hrs. 3(3-0)

Course Objectives

The aim of this course is to introduce the fundamental principles and concepts of classical mechanics. The course objectives are:

1. To develop the basic knowledge of the classical world using the laws of Physics
2. To develop the understanding of two bodies of central force
3. To give an understanding of the kinematics and dynamics of rigid bodies
4. Development of Hamiltonian equation and use of canonical transformation in classical physics

Course Contents:

ELEMENTARY AND VARIATIONAL PRINCIPLES

A brief survey of Newtonian mechanics of single and system of particles, Constraints, D-Alembert's principle, Lagrange's equation, and its applications. Calculus of variation and Hamilton's principle, Derivation of Lagrange's equation from Hamilton's principle

TWO BODY CENTRAL FORCE PROBLEM AND HAMILTON EQUATION OF MOTION:

Two-body central force problem and its reduction to the equivalent one-body problem, the equation of motion and solution for one body. The Kepler laws, laboratory and center of mass Co-ordinate systems and their mutual transformation, Rutherford scattering formula, Legendre transformation and Hamilton equation of motion, Cyclic coordinates conservation theorems and physical significance of the Hamiltonian for simple cases

CANONICAL TRANSFORMATIONS:

The canonical transformation and their examples, Lagrange's and Poisson's brackets, Liouville's theorem small oscillations and normal modes.

THE KINEMATICS OF RIGID BODY MOTION

Rotations in three dimensions, orthogonal transformation, Eulerian angles, Coriolis force.

SPECIAL THEORY OF RELATIVITY

Michelson-Morley experiment, Einstein's postulates of relativity, Lorentz transformation, Geometry of space and time, Addition of velocities, Kinetic energy of relativistic particles, Mass energy relation, Momentum of relativistic particles, Energy equation of charge particle including electromagnetic potential, Orthogonal transformation in three dimensions, Lorentz transformation as orthogonal transformation.

<u>BOOK RECOMMENDED:</u>

1. 'Classical Mechanics', H. Goldstein, Pearson, 2nd. Edition, 1980.

BOOKS FOR REFERENCE:

1. Mathematical Methods of Classical Mechanics, V.I. Arnold, Springer Verlag, New York, 1980.
2. Classical Mechanics', R.A. Matzner & L.C. Shepley, Prentice Hall Inc., International Edition, 1991.
3. Mathematical Physics', Satya Parkash, S Chand & Sons, IVth Edition, 2005

PHY-5503: Methods of Mathematical Physics-I Credit Hrs. 3(3-0)

Course Objectives:

The main aim of this course is to provide the student with a clear and logical presentation of the basic concepts and principles of Vectors, functions of several complex variables, and their applications. This course helps the students to develop the ability to think logically, analytically, and abstractly. The goal of the course is to enable the students:

1. To solve the different problems related to the vectors
2. To solve and understand the problems related to complex variables.
3. To solve Eigenvalue problems

Course Contents:

ADVANCED VECTOR AND TENSOR ANALYSIS

Transformation properties of vectors, Vector differentiation, Scalar, and vector fields, Gradient, Divergence, and Curl of vectors, differentiation with respect to an arbitrary parameter, say, time orthogonal-curvilinear co-ordinates, Representation of operator in cylindrical and spherical polar co-ordinates, vector integration, Line, Surface and volume integration, stokes theorem, Gauss's theorem and Green's theorem,

COMPLEX VARIABLES

Analytic functions, Types of functions, Type of singularities, Branch cut, Branch points, Theorem of Morera, Maximum Modulus Theorem, Cauchy-Rieman Condition, Taylor and Laurents series, Complex Integration, Cauchy's Theorem, Cauchy's Integral Formula, Residue theorem, Examples of Integration.

MATRICES

Linear vector spaces, orthogonal system, linear transformation of Bases and operators, Matrices (basic definitions), orthogonal matrices, Hermitian and unitary matrices, Diagonalisation of matrices, Solution of eigenvalue problems.

RECOMMENDED BOOKS:

1. G. Arfken, Mathematical Physics, Academic Press 2nd Ed. (1970).

REFERENCE BOOKS:

1. E. Butkov, Mathematical Physics, Addison-Wesley 1968.
2. Pipes and Harvill, Applied Mathematics for Engineers and Physicists, McGraw Hill, 1971.
3. Sadri Hassani, Mathematical Physics A Modem Introduction to Its Foundations, Springer-Verlag (2002)
4. N. M. Temme, Special Function, An Introduction to the Classical Functions of Mathematical Physics,John Wiley and Sons (1996)
5. M. R. Speigel, Complex Variables Schaum's Outline Series, McGraw Hill (1979).

PHY-5504: Electromagnetic Theory-I Credit Hrs. 3(3-0)

Course Objectives

This course aims to provide the student with a solid understanding of the fundamentals of electromagnetic fields and their applications in physical phenomena. The objectives are to enable the students to understand the concepts of:

1. Static electromagnetic fields and time-dependent electromagnetic fields
2. Electrostatics, electrical potential, energy density, and their applications.
3. Magnetostatics, magnetic flux density, scalar and vector potential, and its applications.
4. Faraday's law induced emf and their applications.

Course Contents:

ELECTROSTATIC FIELDS

Review of Coulomb's law, Electric Field intensity, Electric Potential, Gauss's law and its application, Field and potential due to a charge distribution, Electric Dipole, Linear quadrupole and multipole due to charge distribution, Coefficient of capacitance and inductance, potential energy of a charge distribution, energy density in an electric field, forces on conductors.

DIELECTRICS

The electric polarization, Electric displacement D, Electric susceptibility, The dielectric coefficient, Calculation of Electrostatic field involving dielectrics, Dielectric sphere with a point charge at its center, Calussius Mossotti equation, Potential energy of a charge Distribution in the presence of dielectrics, Laplace and Poisson's equation, Boundary conditions, Uniqueness theorem, Images for plane and spherical surface, Images in dielectrics, Charge near a semi-infinite dielectric, Solution of Laplace's equation for rectangular and spherical systems.

MAGNETIC FIELDS OF STEADY CURRENTS

Magnetic forces, Magnetic induction, The Biot-Savart law and its applications, The Lorentz force on a point charge moving in a magnetic field, parallel plate magnetron, the divergence of the magnetic induction B, the vector potential A, Equation of continuity, Divergence of the vector potential, The Curl of magnetic Induction, The Ampere's circuital law and its applications, Magnetic scalar potential, Magnetic dipole moment of a current loop, Ampere Circuital law and the Scalar potential.

Recommended Books:

1. D. J. Griffiths, An introduction to Electrodynamics, Prentice Hall, 3rd edition (1984)

Reference Books:

1. P.C. Lorrain & D.R. Corson, 'Electromagnetic Fields and Waves', W.H. Freeman & Co., New York (1978).
2. D. J. Griffiths, An introduction to Electrodynamics, Prentice Hall, 3rd edition (1984)
3. C.R. Paul & S.A. Nasar, 'Introduction to Electromagnetic Fields, McGraw Hill Book Company, Singapore (1987).
4. Electromagnetism with applications, Lorrain and Corson, W.H. Freeman & Co., New York (1978).
5. C.R. Paul & S.A. Nasar, 'Introduction to Electromagnetic Fields, McGraw Hill Book Company, Singapore (1987).
6. H.C. Ohanion, 'Classical Electrodynamics', Allyn & Bacon Inc., Massachusetts (1988).
7. A.M. Portis, 'Electromagnetic Fields', John Wiley & Sons, New York (1978).

PHY-5505: Electronics Credit Hrs. 3(3-0)

Course Objectives

The aims of this course are to familiarize the student with functional principles and analysis of fundamental electronic circuits and devices and simple methods for designing. The acquired knowledge will allow students to take part in wide-outlined teams in industrial equipment development. After successfully completing this course, the student will be able to:

1. Demonstrate a good understanding of the fundamental principles underlying basic electronics.
2. Construct and design simple electronic circuits.
3. Analyze electronic circuits both independently and collaboratively.
4. Identify and solve problems involving electronics.
5. Communicate the understanding of electronics both verbally and in written form.

Course Contents:

ELECTRICAL CONCEPTS AND THEOREMS

Basic Electrical concepts (Ohm & Kirchhof Laws), Circuit elements (Active and passive) behaviors, Transformer (introduction), Branch, Mesh, and Node analysis (dc analysis only), Wave filters (Low & high), Circuit Theorems (Thevenin, Norton, Superposition and Maximum power transfer theorems, DC analysis)

SEMICONDUCTOR DIODE CHARACTERISTICS AND APPLICATIONS

PN-Junction Diode, Ideal and Real Behaviour and Characteristics, Junction Capacitance, Reverse Recovery Time, Frequency response, Temperature effect, Diode as a Rectifier, Half wave, Full wave and Bridge Rectifier, Smoothing Circuit, Diode Clipper and Clampers, Zener diode, voltage regulation.

BJT CHARACTERISTICS AND DC BIASING

BJT, Transistor Characteristics such as CBC, CEC, CCC, Transistor Voltage amplification, Transistor Biasing, Fixed current Bias, Collector-to-Base Bias, Emitter Current Bias, Temperature Effect, Q-point Operation, Graphical analysis, FET, FET Biasing,

OPERATIONAL AMPLIFIER

Basic Differential Amplifier, Differential Amplifier circuits, Constant Current Sources, CMRR, Basics of the Operational Amplifier Operational Amplifier circuits and specification (Inverting & Non-Inverting), application of Operational Amplifier (as summing, comparator, integrated and differentiator).

FEEDBACK AMPLIFIER AND OSCILLATOR

Feedback concepts, Feedback connection types, Feedback amplifier, Phase and frequency consideration, Oscillator operation, Phase Shift oscillator, Wien Bridge oscillator, Hartly oscillator, Amplitude stabilization.

FUNDAMENTAL OF DIGITAL ELECTRONICS

Review of number systems, Binary operation, Digital codes, Logic gates, Boolean Algebra, Logic expression (SOP, POS), Simplifying logic circuits, Designing of combinational logic circuits, intro. To sequential logic circuits, Flip flops (SC, JK, D-Flip flop), and Monostable and Astable multivibrators.

Recommended Books

1. Bell D., Electronic Devices and Circuits, Tata McGraw-Hill, 5^{th} Ed. (2009)
2. Floyd L. Thomas, Electronic devices, Prentice Hall., 7^{th} Ed. (2002)
3. Floyd l. Thomas, Digital Fundamentals Tata McGraw-Hill, 8^{th} Edition.(2003)
4. Nashelsky I Boylstad R., Electronic Devices and Circuit Theory. Prentice Hall. (2010)
5. Horowitz and Hill, The Art of Electronics, Cambridge University Press 2^{nd} Ed. (1989)
6. Floyd L. Thomas, Principles of electric circuits, Prentice Hall., 7^{th} Ed. (2002)

PHY-5506: Atomic and Laser Physics Credit Hrs. 3(3-0)

Course Objectives

Atomic Physics is the branch of Physics that is concerned with the study of the structure and properties of atoms. It has wide applications in many areas of science and technology, such as its use in medical research and in the semiconductor industry. The aim of the course is to study the developed and developing theories about the structure of atoms and their behavior governed by quantum mechanical principles. An effort has been made for students to understand the following aspects; the spectrum of the Hydrogen atom, assumptions and conclusions of Bohr's model to vector atom model single step & two step transitions between energy levels nature and production of X-rays. Quantum theory of radiation, wave-particle nature, fundamentals of lasers

Course Contents:

ATOMIC STRUCTURE AND ATOMIC SPECTRA

Bohr's theory of Atomic structure and atomic spectra, Correction for nuclear motion, Sommerfeld elliptic orbits, relativity correction, and hydrogen fine structure, Vector model of the atom, Orbital angular momentum, spin angular momentum, total angular momentum, Orbital and spin magnetic moments, magnetic quantum numbers, space quantization, coupling scheme (LS and JJ coupling), Pauli's exclusion principle, distribution of electrons in an atom, spectral notations, Zeeman effect (normal and Anomalous), Spectra of two electrons atom, Inner core electron spectra (X-rays), Stark effect.

QUANTUM THEORY OF RADIATION

The failure of classical Physics to describe atomic phenomena, the emission, and absorption of thermal radiation, the classical theory of thermal radiation and its failure, Plank's quantum theory of thermal radiation.

THE WAVES AND THE PARTICLES

De-Broglie's hypothesis, diffraction of electrons and neutrons, the velocity of the de-Broglie wave, group velocity, and particle velocity.

LASER

Interaction of radiation with matter, Black body radiation, Principles of Laser operation, Pumping process, Passive optical resonators, CW and transient Laser behavior, Q-Switching, Types of Lasers, Laser detectors, Application of lasers.

Recommended Book:

1. Concepts of Modern Physics, Arthur Beiser, Tata McGraw-Hill, 6th Edition, 2011.

Reference Books:

2. Modern Physics, Serway, Moses and Moyer, Thomson Books, 3rd Edition, 2007.
3. Modern Physics, S. L. Kakani, Viva, 1st Edition, 2011
4. Atomic Physics, S. N. Ghoshal, S Chand & Company, 1st Edition, 2011.
5. Physics of the Atom, Wher, Richard, Norasa, 4th Edition, 2002.
6. Atomic spectra and Atomic structure, Herzberg, Dover New York.

Semester-VI

PHY-5601:	Lab-VI (Solid State Physics)	Credit Hrs. 3(1-2)

Course objectives:

The aim of this course is to develop the understanding of students in measuring the thermal and optical parameters and to remove the fear of students using various gadgets in the laboratory. The course objectives are:

1. To make the students confident in their studies by showing and measuring parameters that they have used in theoretical work.
2. To make them familiar with such experiments whose outcome can be used in developing future research capabilities and teaching skills?

List of Experiments

1. To study some aspects of ferromagnetism by drawing a B-H curve.
2. To investigate the Hall Effect in semiconductors or in metals and to draw the graph between Hall voltage and current.
3. To verify Bragg's law for X-ray diffraction by using the rock salt crystal.
4. To expose the Van-Laue pattern of LiF on X-ray film
5. To determine the dielectric constant of a solid by capacitor method.
6. (a) To study the characteristics of the photocell.
   (b) To study the characteristics of a thermistor.

7. To determine the energy gap in Silicon or Germanium.
8. To find the crystal structure of graphite by electron diffraction.
9. To study luminescence.
10. To study the thermoelectric effect by using the heat pump.
11. To study the crystal lattice structure of tungsten by Field emission Microscope.
12. To measurement the resistivity & conductivity of metals & non-metals.
13. To study the characteristics of superconductors.

PHY-5602: Quantum Mechanics-I Credit Hrs. 3(3-0)

Course objectives

1. Introduction to Quantum mechanical operators. Eigen values and its formulism
2. Understanding the behavior of quantum mechanical particles and development of the Schrodinger equation in one and three-dimensions
3. To apply Schrodinger Equation to find the potential problems
4. Determination of angular momentum of a quantum mechanical particle and application of Schrodinger equation for spherical symmetric system.

Course Outlines:

OPERATORS AND EIGENFUNCTIONS

Review of concepts of classical mechanics, State of a system, Properties of the one-dimensional potential function, Postulates of Quantum mechanics, operators, Linear operators, Eigenfunctions and Eigenvalues, Expectation values of observable, The operator formalism in quantum mechanics, orthogonal systems, completeness of Eigen functions, Hermitian operator, Simultaneous Eigen functions and the commutator, The parity operator, The fundamental commutation rule, Ehrenfest theorem, Correspondence principle.

FORMULATION OF QUANTUM MECHANICS

Wave-particle duality, Wave Packets, Heisenberg uncertainty relations, Time evolution of a system, Uncertainty principle and the related Gedenken experiment, Wave function for a free particle, Schrodinger equation, Interpretation of wave function, Probability density and probability current,

APPLICATION OF SCHRODINGER EQUATION

Application of Schrodinger equation for one-dimensional problems, Potential step, Potential barrier and tunneling, Rectangular potential-well, three-dimensional square well potential, linear harmonic oscillator.

SPHERICALLY SYMMETRIC SYSTEMS

Separation of Schrodinger equation in Cartesian coordinates, Central potentials, The Schrödinger equation for spherically symmetric potentials, Degeneracy, Angular momentum, Many-particle system, The hydrogen atom.

Recommended Books:

1. R.L. Liboff, 'Introductory Quantum mechanics', Addison Wesley Publishing Company, Reading Mass. (1980).
2. B.H. Bransden & C.J. Joachain, 'Introduction to Quantum Mechanics' Longman Scientific & Technical London (1990).

3. J.S. Townsend, 'A Modern Approach to Quantum Mechanics', McGraw Hill Book Company, Singapore (1992).
4. W. Greiner, 'Quantum Mechanics: An Introduction', Addison Wesley Publishing Company, Reading Mass. (1980).
5. Bialynicki-Birula, M. Cieplak & J. Kaminski, 'Theory of Quanta', Oxford University Press, New York (1992).

PHY-5603: Methods of Mathematical Physics-II Credit Hrs. 3(3-0)

Course objectives

The aim of this course is to acquaint the student with the techniques of the Fourier series and integral transform and their basic role in different physical applications. The goal of the course is to introduce some of the main ideas of differential equations and provide an opportunity for students to make use of these course contents in scientific applications.

Course Contents:

FOURIER SERIES

Definition of Fourier series, Example of Fourier Series, Fourier sine and Cosine Series, Complex Form of Fourier Series, point-wise and mean convergence of Fourier series, Applications of Fourier series

FOURIER TRANSFORM

Integral transforms, Fourier transforms of derivatives, Fourier sine transform, Fourier Cosine transform, Fourier transformation of generalized functions, Fourier transform and its properties, the connection between Laplace and Fourier transforms, Laplace Transform, its properties, and applications.

SPECIAL FUNCTIONS

Partial differential equations of theoretical Physics, Separation of variables, Singular points, Series solutions, Frobenius's method, Non-homogenous equation, Gamma function (definitions and simple properties), Beta function, Spherical harmonics, Dirac delta function and its properties, Green's Functions.

Recommended Books:

1. G. Arfken, Mathematical Physics, Academic Press 2nd Ed. (1970).
2. E. Butkov, Mathematical Physics, Addison-Wesley 1968.
3. Pipes and Harvill, Applied Mathematics for Engineers and Physicists, McGraw Hill, 1971.
4. Sadri Hassani, Mathematical Physics A Modem Introduction to Its Foundations, Springer-Verlag (2002)
5. N. M. Temme, Special Function, An Introduction to the Classical Functions of Mathematical Physics,John Wiley and Sons (1996)
6. M. R. Speigel, Complex Variables Schaum's Outline Series, McGraw Hill (1979).
7. E. D. Rainville, Special Functions, Macmillan and Company (1971)
8. 2. G. E. Andrews, R. Askey, and R. Roy, Special Functions, Cambridge University Press, (2000)
9. J. W. Brown and R. V. Churchill, Fourier series, and Boundary Value Problems, McGraw Hill (2006).
10. H.K. Dass, R. Verma, Mathematical Physics, S. Chand Company Pvt. Ltd. 7th Ed. New Delhi (2014).

PHY-5604: Electromagnetic Theory-II Credit Hrs. 3(3-0)

Course Objectives

The objectives of this course are:

1. To develop knowledge of the propagation, reflection, and refraction of electromagnetic waves
2. To Familiarize the students with Maxwell's Equations and their physical significance
3. To develop the knowledge of propagation of Plane electromagnetic waves and Poynting vector

Course Outlines:

INDUCED ELECTROMOTANCE AND MAGNETIC ENERGY

Faraday's induction law, Induced Electromotance in a moving system, Inductance and induced electromotance, Energy Stored in a Magnetic field, Self – Inductance for a volume distribution of current, Magnetic force between two currents, and Magnetic Torque.

MAGNETIC MATERIALS

Magnetic dipole moment $\boldsymbol{\mu}_m$ The magnetic polarization Vector **M**, Magnetic susceptibility, Magnetic materials, and their classification, The magnetic induction B from polarized magnetic Material at an exterior point, at an Interior point, magnetic field intensity H, Ampere's Law in magnetic materials, Ferro magnets and Hysteresis, Boundary conditions.

ELECTROMAGNETIC WAVES:

Waves in one dimension, Electromagnetic waves in vacuum, Electromagnetic waves in matter, Absorption, and dispersion, and Guided waves.

MAXWELL'S EQUATIONS And PROPAGATION OF PLANE ELECTROMAGNETIC WAVES IN MATTER:

Maxwell's equation in differential and integral forms, The Poynting Vector, The E and H Vectors in homogeneous, isotropic Linear and Stationary media, Propagation of plane electromagnetic Wave in Non-Conducting and Conducting Media, Propagation of plane electromagnetic waves in Ionized Gases.

Recommended Books:

1. D. J. Griffiths, An introduction to Electrodynamics, Prentice Hall, 3rd edition (1984)

Reference Books:

1. P.C. Lorrain & D.R. Corson, 'Electromagnetic Fields and Waves', W.H. Freeman & Co., New York (1978).
2. D. J. Griffiths, An introduction to Electrodynamics, Prentice Hall, 3rd edition (1984)
3. C.R. Paul & S.A. Nasar, 'Introduction to Electromagnetic Fields, McGraw Hill Book Company, Singapore (1987).
4. Electromagnetism with applications, Lorrain and Corson, W.H. Freeman & Co., New York (1978).
5. C.R. Paul & S.A. Nasar, 'Introduction to Electromagnetic Fields, McGraw Hill Book Company, Singapore (1987).
6. H.C. Ohanion, 'Classical Electrodynamics', Allyn & Bacon Inc., Massachusetts (1988).
7. A.M. Portis, 'Electromagnetic Fields', John Wiley & Sons, New York (1978).

PHY-5605: Nuclear Physics-I Credit Hrs. 3(3-0)

Course Objectives

1. The nuclear structure is in contrast with the atomic structure.
2. The experimental techniques and detectors used to study matter/radiation and their interaction.
3. Radioactive growth, decay, and related parameters.
4. Energy-releasing reactions, when they are possible/not possible, power generation via nuclear process (fission and fusion).
5. The fundamentals of nuclear and particle physics aspects, which are important to modern applications (Medicine, Engineering, Biotechnology etc.).
6. Fundamental particles and their interactions (strong, weak and electromagnetic).
7. The useable knowledge of physics behind the nuclear concepts.

Course Contents

BASIC PROPERTIES

Proton-electron theory of the nucleus, Proton-neutron theory of the nucleus, Size, Mass, Binding energy, Dipole and quadruple moments (electric) parity, and statistics of nuclei.

RADIOACTIVITY

Introduction to radioactivity, Laws of radioactive disintegrations, Half and mean life of radioactive isotopes, Natural radioactive series. The stability of heavy nuclei against alpha emission, Theories of alpha decay (Classical and Quantum mechanical), Alpha-particle spectra, Measurements of alpha-particle energies and velocities, Introduction to the classical theory of beta decay, The beta decay, The velocity and energy of beta-particles, Beta-particles spectra, Neutrino Hypothesis Fermi theory of beta-decay, Parity violation in beta-decay, Electron capture, introduction to Gamma decay, Multipolority of gamma-radiations, Measurements of Gamma rays energies: Using NaI (Tl) detector,

NUCLEAR REACTIONS

Conservation laws of nuclear- reactions, Q-value and threshold energy, Theory of Compound Nucleus, Nuclear cross-section, Reaction induced by photons, Protons, Deuterons, and alpha particles,

PARTICLE DETECTORS AND ACCELERATORS

Passage of charged particles through matter, Energy loss and stopping power, G.M counter, Proportional counter, Ionization chamber, Semiconductor Detector, Scintillation counter, Linear accelerator, Betatron, Cyclotron

Books Recommended:

1. Irving Kaplan, Nuclear Physics, Addison-Wesley Publishing Co., 2002.
2. Evans, The atomic nucleus, McGraw Hill, 1965.
3. E. Segre, Nuclei and particles, The Benjamin/ Cummings publishing company, 2nd Edition, 1982.

PHY-5606: Solid State Physics -I Credit Hrs. 3(3-0)

Course Objectives

The course will provide a valuable theoretical introduction and an overview of the fundamental applications of the physics of solids. This course includes a theoretical description of crystal and electronic structure, lattice dynamics, and optical properties of different materials. The objectives of this course are to enhance the knowledge of Solid State Physics with an emphasis on the following concepts:

1. Crystallography
2. Bonding
3. X-ray diffraction, Reciprocal lattice
4. Phonons, Dispersion relations for Phonons
5. Heat Capacities and the semiconducting properties of Solids.
6. Electrical Properties of solids

Course Contents:

CRYSTAL STRUCTURE

Lattices (Bravais and non-Bravais lattices), Primitive and non-primitive unit cell, Wigner-Seitz unit cell, Symmetry and symmetry operations, Miller indices and planes, Classification of lattices, 2-dimensional and 3-dimensional lattices, (NaCl, CsCl, ZnS and diamond lattices).

CRYSTAL DIFFRACTION

Bragg's law, Reciprocal Lattice, Diffraction conditions, Von-Laue equation, Ewald's Sphere, Brillouin zones, Experimental techniques of X-ray diffraction (Laue method, Rotating crystal method, Powder method)

CRYSTAL BINDING

Review of chemical bondings, Covalent bonding, Metallic bonding, Hydrogen bonding, Ionic bonding, cohesive energy of ionic crystals, Van-der-Waals bonding, Van-der-Waals London interaction.

LATTICE VIBRATIONS AND THERMAL PROPERTIES OF SOLID

Dispersion relation of phonons for one-dimensional Mono-atomic and Diatomic linear lattices, Quantization of Elastic Waves Phonons, -Phonon Momentum. Lattice heat capacity, Dulong and Petit Law for the specific heat of solids, Einstein Model of specific heat of solids, Debye model of specific heat of solids with high and low-temperature limitations

FREE AND NEARLY FREE ELECTRON MODELS

Energy levels and density of orbital in one dimension, Hall effect, Nearly free electron model, Origin of the energy gap, Magnitude of the energy gap, Bloch functions, Kronig-penney model, the structure of Brillouin zones, Reduced zone scheme, periodic zone scheme, and extended zone scheme.

Recommended Books

1. C. Kittel, Introduction to Solid State Physics, John Wiley & Sons 8th.ed., (2005)
2. R. J Elliot and A. F. Gibson; ELBS and Macmillan, An Introduction to Solid State Physics and its Applications,
3. M. A. Omar, Elementary Solid State Physics, Pearson Education 2000.
4. N. M. W. Ashcroft and N. D. Mermin, Solid State Physics, Holt, Rinehart & Winston, 1976.
5. J. S. Blackmore; W. B. Saunders, Solid State Physics,
6. Ziman, Principle of Solid State Physics, Cambridge University.
7. H. E. Hall John, Solid State Physics, ELBS, and John Wiley & Son.
8. M.A. Wahab, Solid State Physics, Narosa Publishing House, 1999.

Semester-VII

PHY-6701: Lab-VII (Nuclear Physics) Credit Hrs. 3(0- 3)

Course objectives:

The aim of this course is to develop the experimental capability of students to understand the concept of Nuclear physics. The course objectives are:

1. To make them familiar with such experiments whose outcomes can be used in developing future research capabilities and teaching skills.
2. To study the characteristics of a Geiger-Muller counter and to examine the attenuations of beta particles in Al-and Pb foils
3. To understand the behavior of nuclear radiation, including beta and gamma radiation

List of Experiments

1. To draw the G M Tube's characteristics
2. To find the dead time of a G M Tube.
3. To study the exponential decrease in the intensity of gamma rays with thickness and determination of the linear absorption coefficient and mass absorption coefficient of lead.
4. To study the statistics fluctuation in the emission of gamma rays and to compare the theoretical and experimental curves.
5. Determination of the range of Alpha particles using the solid-state detector.
6. Determination of the maximum energy of beta particles.
7. Determination of half-life of thoron gas
8. To verify the inverse square law of nuclear radiations.
9. Detection of g-rays by sodium iodide (NaI) detector system

PHY-6702: Quantum Mechanics-II Credit Hrs. 3(3-0)

Course objectives

1. To understand the use of matrix mechanics in quantum physics.
2. To solve the angular momentum and spin in matrix representation
3. Use of approximation in quantum mechanics
4. To understand the use of approximation in quantum mechanics
5. To understand the theory of scattering and interaction of quantum systems with radiation
6. To understand the basics idea about identical particles.

Course Contents:

MATRIX MECHANICS

Restatement of quantum mechanical assumptions, Matrix operators, Bra and Ket vectors, Schrodinger, Heisenberg and interaction pictures of quantum mechanics, the one-dimensional harmonic oscillator in Matrix mechanics.

ANGULAR MOMENTUM AND SPIN

Matrix representation of angular momentum and its components, Explicit forms of angular momentum matrices, Effect of the magnetic field, Quantum theory of normal Zeeman effect, Electron spin and the Pauli spin matrices, electronic states in a central field, Addition of angular momenta, The P-states of an electron, Spin states for two particles of spin one-half.

METHODS OF APPROXIMATION

Variational methods and their application, perturbation theory for non-degenerate stationary states with a simple illustration, time-dependent perturbation, WKB Approximation. Transition probability and Fermi`s Golden Rule.

THEORY OF SCATTERING

Derivation of scattering cross section by partial wave technique, scattering by an attractive square well potential, Born approximation, Scattering by coulomb field, optical theorem.

IDENTICAL PARTICLES

Principle of indistinguishability of identical particles, Generalized Pauli's Exclusion principle, Statistics of identical particles, helium atom, Symmetric, and anti-symmetric wave functions.

Recommended Books

1. R.L. Liboff, 'Introductory Quantum mechanics', Addison Wesley Publishing Company,
   Reading Mass. (1980).

Reference Books

1. B.H. Bransden & C.J. Joachain, 'Introduction to Quantum Mechanics' Longman Scientific
   & Technical London (1990).
2. J.S. Townsend, 'A Modern Approach to Quantum Mechanics, McGraw Hill Book Company, Singapore (1992).
3. W. Greiner, 'Quantum Mechanics: An Introduction, Addison Wesley Publishing Company, Reading Mass. (1980).
4. R.L. Liboff, 'Introductory Quantum mechanics', Addison Wesley Publishing Company,
   Reading Mass. (1980).
5. Bialynicki-Birula, M. Cieplak & J. Kaminski, 'Theory of Quantua', Oxford University Press, New York (1992).

PHY-6703: Plasma Physics Credit Hrs. 3(3-0)

Course Objectives

This course provides an understanding of basic concepts of plasma and the theoretical concepts, which are important in determining the behavior of both naturally occurring plasmas and plasmas used in industrial applications. The aims of this course are:

1. To provide the students with an understanding of the broad range of physical phenomena which determine the behavior of plasmas and the importance of collective effects,
2. To provide the skills necessary to solve problems in plasma physics and in the process to enhance the students analytical abilities and problem-solving skills,

3. To provide an understanding of the principles involved in thermonuclear fusion ignition and an appraisal of the different approaches to achieving this,
4. To enable the student to build up models of plasmas from the microscopic descriptions of the behavior of single charged particles in electric and magnetic fields through the statistical treatment of large numbers of particles and their collective phenomena.

Course Contents:

INTRODUCTION TO PLSMA

General properties of Plasma, the definition of plasma, plasma as the fourth state of matter, plasma production, plasma interaction, and collision effects, some basic plasma phenomena, criteria for the definition of plasma, Macroscopic neutrality in plasma, Debye shielding, Plasma frequency.

SINGLE PARTICLE MOTION

The Motion of a particle in the presence of E and B fields, non-uniform B field, non-uniform E field, time-varying E field, and time-varying B field. Plasma as a Fluid Introduction, Relations of plasma Physics in ordinary electromagnetics, the fluid equation of motion, the fluid drifts perpendicular to B field, the fluid drifts parallel to B field, the plasma approximation.

WAVES IN PLASMA

Waves in a cold plasma, Fourier representation of waves, plasma oscillations, electron and ion waves, sound waves, electrostatic ion waves perpendicular to magnetic field, lower-hybrid frequency, Electromagnetic waves for un-magnetized and magnetized plasmas, Alfven waves, magneto-sonic waves.

CONTROLLED FUSION

Introduction to controlled fusion, Basic nuclear fusion reactions, reaction rates, power rates, and power density, radiation losses from plasmas, and operational conditions.

Recommended Books

1. F. F. Chen and J. P. Chang, Kluwer, Principles of Plasma Processing, Academic/ Plenum Publishers New York (2003).
2. J. A. Bittencourt. Pergamon, Fundamentals of Plasma Physics, Press Oxford (1995).
3. H. Hutchinson, Principles of Plasma Diagnostics, Cambridge University Press New York (1999).
4. J. Reece Roth, Industrial Plasma Engineering, Institute of Physics Publishing Bristol (2000).
5. N Orlando Auciello and Daniel L. Flamm, Plasma Diagnostics, Academic Press Boston (1989).

PHY-6705: Nuclear Physics-II Credit Hrs. 3(3-0)

Course objectives

It gives the details of;

- Radioactivity, half-lives and relevant parameters, masses and energies, isotopes and artificial radioactivity.
- The mechanics of α, β and γ decay, classical and Quantum Mechanical theories related to these.
- Some basic concepts of elementary particles.

Course Contents:

NEUTRON PHYSICS

Production of neutrons, Detection of neutrons, the interaction of neutrons with matter in Bulk, Thermal neutrons, Neutron reactions and cross-section, the diffusion of thermal neutrons, and Scattering.

NUCLEAR FISSION AND FUSION

Discovery of fission, Types of fission, Theory of fission (Bohr and Whealer's theory), Weizeker mass formula, Mass and energy distribution in fission, Controlled fission reaction, Fission Reactors, Fission Explosive, Basic Fusion reaction, Characteristics of fusion

NUCLEAR FORCES

Two body problem, Deuteron (Properties of Nuclear force, Ground state of Deuteron No Excited S-states, Exited states of the deuteron). Yukawa's theory of nuclear forces,saturation on Nuclear forces (Exchange forces, isotopic spin formalism), Scattering cross sections, Neutron-Proton scattering at low energy, Proton-Proton scattering at lowenergy, Similarity between (n-n) and (p-p) forces.

NUCLEAR MODELS

Introduction, Fermi gas model, Liquid drop model, Shell model, evidence for the existence of magic numbers, Extreme single particles model (square well potential, Harmonic oscillator, Spin-orbit potential), Individual (independent) particle model, Prediction of shell model, Collective nuclear model.

ELEMENTARY PARTICLE

Introduction and Production of elementary particles, Classification, Interaction and their types. Classification of elementary particles.

Book Recommended

1. Kenneth Krane, Introduction to Nuclear Physics, John Wiley & Sons, 2^{nd} Edition, 1987
2. Glen F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 2nd Edition, 1989.
3. E. Segre, Nuclei and particles, The Benjamin/ Cummings publishing company, 2nd Edition, 1982.
4. William J. Price, Nuclear radiation and Deduction, McGraw Hill New York.1964.
5. Irving Kaplan, Nuclear Physics, Addison-Wesley Publishing Co., 2002.

PHY-6705: Solid State Physics – II Credit Hrs. 3(3-0)

Course Objectives

This course includes theoretical descriptions and properties of different materials based on classical and quantum physics principles. A considerable attention is devoted to superconductivity, not only because superconductors are a part of the research interest of to a number of worldwide groups but mostly because they illustrate a number of important concepts in solid-state physics. The students are expected to develop a deeper understanding of some fundamental practical tools of physics of solids necessary to comprehend all the forthcoming more advanced courses.

Course Contents:

SEMICONDUCTOR CRYSTALS

Review of Band Structure in semiconductors, Crystal structure and bonding band structure, Band Structure of Semiconductors, Impurity states, Donor states, Accepter states, Holes, Effective Mass Intrinsic Carrier concentration (law of mass action), p-n junction, Rectification Solar cell, and photovoltaic detectors.

DIELECTRICS AND FERROELECTRICS

Dielectric Material, Dielectric polarization mechanism, Dielectric Constant and polarizability, Electronic polarizability, Ferroelectric crystals, Classification of ferroelectric crystals, Polarization catastrophe.

DIAMAGNETISM AND PARAMAGNETISM

Langevin diamagnetism equation, Paramagnetism, Quantum theory of Paramagnetism, Crystal field splitting, Quenching of the orbital angular momentum, Cooling by adiabatic demagnetization of paramagnetic salt, Paramagnetic susceptibility of conduction electrons.

FERROMAGNETISM

Ferromagnetic order, Curic point and exchange integral, the Temperature dependence of the saturation magnetization, Saturation magnetization at absolute zero, Magnons, Thermal excitation of magnons.

SUPERCONDUCTIVITY

Occurrence of Superconductivity, Destruction of Superconductivity by Magnetic fields, Meissner effect, Thermodynamics of the superconducting transition, London equation, Coherence length, BCS Theory of superconductivity.

Recommended Books

1. C. Kittel, Introduction to Solid State Physics, John Wiley & Sons 8th.ed., (2005)

Reference Books

2. R. J Elliot and A. F. Gibson; ELBS and Macmillan, An Introduction to Solid State Physics and its Applications,
3. M. A. Omar, Elementary Solid State Physics, Pearson Education 2000.
4. N. M. W. Ashcroft and N. D. Mermin, Solid State Physics, Holt, Rinehart & Winston, 1976,
5. M.A. Wahab, Solid State Physics, Narosa Publishing House, 1999.

Semester-VIII

PHY-6801: Lab-VIII (General Physics) Credit Hrs. 3(3-0)

Course objectives:

The aim of this course is to expose the students to advance level experimentation in Physics. The course objectives are:

1. To make them familiar to such experiments whose outcome can be used in developing future research capabilities and teaching skills?
2. To make them familiar to such experiments whose outcome can be used in developing future research capabilities and teaching skills?

List of Experiments

1. Michelson's Interferometer
   (i) To measure the wavelength of sodium light
   (ii) To measure the difference in wavelength
   (iii) To measure the thickness of the thin films.
2. To study of parameters of the Laser beam.
3. To measure the Planck's constants by photoelectric apparatus.
4. To measure Planck's constants by hydrogen discharge spectrum.
5. To determine the ratio of e/m of an electron by J. J. Thomson's method.
6. To verify the quantization of energy band by Franck - Hertz experiments.
7. To determine the (g) factor by Electron spin Resonance (ESR).
8. To find the fine structure of one electron spectrum or two electron spectra.

PHY-6802: Statistical Mechanics and Thermal Physics Credit Hrs. 3(3-0)

Course objectives

The aim of this course is to present the fundamental ideas and methods of statistical mechanics and thermodynamics, and to develop these ideas through simple examples. The course goals are:

1. Explain the laws of thermodynamics in their various forms and explain their physical significance.
2. Derive and state Maxwell's relations and apply them to problems in thermodynamics.
3. State the thermodynamic potentials and recognize the most appropriate potential for application to a particular problem.
4. Derive and state the Boltzmann, Fermi-Dirac and Bose-Einstein distributions.
5. To know the key links between thermodynamics and statistical mechanics and apply these to problems.
6. Be able to explain the importance and significance of the partition function, and be able to construct partition functions for systems and extract thermodynamic properties from them.

Course Contents:

THERMAL PHYSICS

Review of laws of thermodynamics, Maxwell's Relations Thermodynamic potentials, Criteria of Thermodynamical equilibrium, Intrinsic and mutual Stabilities of single component systems, conditions of Stabilities. The Lechatelier Braun Principle, First order phases transition, Discontinuities of volume and entropy. Second order phase transition, Kinetic theory of gases.

STATISTICAL MECHANICS

Fundamental principles, Mean values and Probability distributions Statistical ensemble, Probability, and entropy relationship, Liouville's theorem, Statistical concept of temperature, Entropy and free energy, Micro canonical, Macro-canonical and grand canonical ensembles, Macro & Microstates, Maxwell's Boltzmann statistics and its application to (i) equipartition of energy, (ii) Harmonic oscillator, (iii) Richardson's equation for thermionic emission (iv) Paramagnetism, Quantum statistical mechanics-basic facts of quantum mechanics, Heisenberg uncertainty principle and Bose-Einstein statistics; its application to black body radiation, Pauli exclusion principle and Fermi-Dirac statistics; its application to electron gas, Specific heat of electron gas, Thermionic emission, Kinetic methods, and transport theory, Boltzmann transport equation, and its application,

Recommended Books

1. C. Kittel and H. Kroemer, Thermal Physics, W. H. Freeman and Co New York 2nd edition (1980).
2. Raj Kumar Pathria, Statistical Mechanics, Pergamon P., 2nd edition (India, 1996)
3. F. H. Grawford, Heat Thermodynamics, and Statistical Physics, Harcourt, Brace & World, 6th edition 1963.
4. F. Rief, Statistical Physics, McGraw-Hill Inc., Volume. 5, (2008).
5. F. Rief, McGraw Hill, Fundamental of statistical and thermal Physics, Waveland Pr. Inc, (1965).
6. Kerson Huang, Introduction to Statistical Physics, Taylor and Francis Alpha Science Intl Ltd., Volume 51 (2000).
7. Tanaka, Methods of Statistical Physics, Tomoyasu Tanaka 1st Edition (2002).
8. H. B. Callen, Thermodynamics and an Introduction to Thermo-statistics, Wiley, Volume 22 (1985).
9. Gugenheim, an Introduction to Applied Statistical Thermodynamics, Wiley, 2nd Edition (1950).
10. Zemansky, Heat and Thermodynamics, McGraw-Hill, Inc., 6th Edition (1997)

PHY-6803: Computational Physics Credit Hrs. 3 (2-1)

Course Objectives

This course is intended to give an introduction to main computational tools, techniques and methods used in contemporary physics. Student will practice writing, compiling, and running computer programs, together with analysis of results, and presentation of their results as scientific reports. The main objective of this course is to develop the programming skill of the students and it also focus on practical methods for solving physics problems.

Course Contents:

INTRODUCTION TO COMPUTING

Introduction (What is computational physics?), Tools of computational physics, Overview of Computer Fortran Languages (90/95), Programming Fundamentals (Comments, statements, blocks, identifiers, keywords, literals, Primitive data types, Variables, Operators, Operator Precedence), Control Structures (if, else, switch, while, do-while, for, break, continue, return), Arrays in Fortran, Function, File structure

NUMERICAL METHODS

Numerical Solutions of equations, Regression and interpolation, Numerical integration and differentiation, Error analysis, and technique for elimination of systematic and random errors.

APPLICATION TO PHYSICS

Some systems of interest for physicists such as Motion of Falling objects, Kepler's problems, Oscillatory motion, Many-particle systems, Dynamic systems, Wave phenomena, Field of static charges and current, Diffusion, Population genetics, etc.

Recommended Books

1. M. L. De Jong, 'Introduction to Computational Physics', Addison Wesley Publishing Company Inc., Massachusetts (1991).
2. S.C. Chapra & R.P. Chanle, 'Numerical Methods for Engineers with Personal Computer Applications, McGraw Hill Book Company, New York (1965
3. S.T. Koonini, Computational Physics', the Benjamin/Coming Publishing Inc., California (1986).
4. P.K. Macheown & D.J. Merman, Computational Techniques in Physics' Adm Hilger, Bristol (1987).
5. H. Gould & J. Tobochnik, 'An Introduction to Computer Simulation Methods', Addison Wesley Publishing Company, Rading Massachusetts (1988).

OPTIONAL COURSES (SEMESTER-VIII)

PHY-6805: Magnetism in Condense Matter Credit Hrs. 3(3-0)

Course Objectives

The course will introduce advanced concepts of magnetism in condensed matter either to excite the mind to pursue a condensed matter career or to give a fair overview of the subject to the audience with ambitions towards other disciplines of physics. The approach integrates the basic physics of magnetism with materials science, and the subject matter is developed at a level that enables students to understand magnetism and magnetic materials at the forefront of the field and to enthusiastically read the current research and technological literature. The students is expected to develop a deeper understanding of some fundamental practical tools of physics of magnetism necessary to comprehend all the forth coming more advance courses.

Course Contents:

BASIC CONCEPTS AND DEFINITIONS

Magnetic Poles; Magnetic Field, Field Intensity, Magnetic Moment; Magnetic Dipoles, The Bohr magneton, Magnetization Curves, M-H Loops, B-H Loops, Hysteresis Experimental methods, Magnetic measurements, Demagnetizing Fields, Susceptibility and permeability

ATOMIC ORIGIN OF MAGNETISM

Magnetic Moments of Atoms, Molecules and Ions, electron spin, Quantum mechanics of spin, Pauli Exclusion Principle, spin orbit coupling, Hund’s rules, and atomic structure of transition metals

MAGNETISM IN SOLIDS

Diamagnetism, paramagnetism (Langevin theory, Curei-Weiss law, Quenching of orbital angular momentum, Pauli paramagnetism), Ferromagnetism; Weiss theory; Band theory

Exchange interactions, Magnetic domains and the magnetization process, magnetization reversal, Domain wall , wall processes and rotation , Introduction to anti-ferromagnetism, Weisss Model, Neel’s Theory of anti-ferromagnetism, The effect of a strong magnetic field, Types of anti-ferromagnetic order, Measurement of magnetic order

ANISOTROPY OF FERROMAGNETIC CRYSTALS:

Peculiarities of the description of ferromagnetic crystals-magnetostriction, Origin of various kinds of magnetic anisotropies, anisotropy in ferromagnetic of different symmetry magnetic anisotropy energy, corresponding to zero strains zero stresses equilibrium directions of spontaneous, magnetization- magnetic anisotropy measurement.

Recommended Books

1. B.D. Cullity, Introduction to Magnetic Materials, IEEE press 2nd edition (2009)
2. D. Jiles, Introduction to Magnetism and Magnetic, John Wiley & Sons, INC 2nd edition (2000).
3. N. Spaldin, Magnetic Materials, Cambridge university press 2nd edition (2003)
4. ROBERT C. O'HANDLEY, Modern Magnetic Materials Principles and Applications, John Wiley & Sons, INC 2nd edition (2000).
5. S. Blundell, Magnetism in condense matter, oxford university press (2001)

PHY-6806: Environmental Physics Credit Hrs. 3(3-0)

Course Objectives:

The course objectives of environmental physics typically revolve around understanding the physical principles that govern various environmental processes and phenomena.

Course Contents:

Structure and composition of the Atmosphere, Solar Radiation, and the atmosphere, Winds in the atmosphere, The hydrosphere, The ground (soil), Physical behavior of soil water system, soil mechanics, Energy and the environment, Sound and noise, Atmospheric pollution due to nuclear radiations, Non-radioactive, Atmospheric pollution, climatology and measurements of climate factor, Environmental spectroscopy.

Recommended Books

1. Introduction to Environmental Physics, Nigel Mason and Peter Hughes, Taylor and Francis Inc. 2002.
2. Environmental Physics, E. Boeker and R. van Grondelle's, Wiley, 1995.
3. Fundamentals of Weather and Climate, Robin McIlveen, OUP Oxford, 2nd ed. 2010.
4. Energy, Resources and Environment, Eds., J. Blunden and A. Reddish, A Global World. New York, Oxford University Press 1995.

PHY-6807 Renewable Energy Sources Credit Hours: 3(3-0)

Course Objectives:

The course objectives for a Renewable Energy Sources course typically focus on providing students with a comprehensive understanding of different renewable energy technologies, their applications, advantages, and challenges.

Course Contents

Introduction:

Importance of Energy, World energy demand, Conventional energy sources, Renewable energy sources; potential, availability and present status of renewable energy sources, Solar Energy, Physical principle of the conversion of solar radiation into heat, Flat Plate Collectors, Concentrating Collectors, Basic Principles and components of Wind Energy Conversion Systems, Types and performance of Wind Machines, Biomass Conversion Technologies, Thermal Gasification of Biomass, Alternative Liquid Fuels, Biogas Generation, Classification of Biogas Plants,

Sources:

Geothermal Sources, Hydro-Thermal, Geo-Pressure, Petro-Thermal and Magma Resources, Advantages and Limitations of Geo-Thermal Energy, Introduction, Global Generation, Growth Rate, Prospects of Nuclear, Safely and Health Hazards Issues, Global Resources and their Assessment, Classification, Micro, Mini, Small and Large Resources, Principles of Energy Conversions, Turbines, Working and Efficiency of from Micro to Small Power Systems, Environmental Impact.

Books Recommended:

1. Solar Energy Utilization by G.D. Rai, Khanna Publishers-Delhi (1991).
2. Renewable Energy Sources; John W. Twidell and Anthony D. Weir, E &F.N Spon Ltd. London 1986.
3. A Practical Guide to Solar Electricity, Simon Roberts; Prentice Hall Inc. USA, 1991.
4. Solar Engineering Technology; Ted. J. Jansen, Radiation; Prentice Hall Inc. USA, 1985.
5. Wind Power, V. Daniel Hunt, Litton Educational Publishing Inc. 1981.
6. Solar Hydrogen Energy Systems, Ed. T. Ohta, Pergamon Press, 1979.
7. Solar Energy Conversion, Eds., A. E. Dixon and J.D. Leslie, Pergamon Press, 1979.
8. Biogas, Production and Utilization, Elizabeth C. Price, Paul N. Cheremisinoff; Ann Arbor Science, USA, 1981.
9. Biomass, Catalysts and Liquid Fuels; Ian Campbell, Technonic Publishing Co. Inc, USA, 1983.

PHY-6808: Radiation and Medical Physics Credit Hrs. 3(3-0)

Course Objectives

The course will demonstrate to the student the theoretical background, mode of operation and practical application of systems designed to image either anatomy or physiological function using ionizing radiation. It will also introduce the student to the methods by which images can be processed and assessed. The course objectives are:

1. To impart knowledge on the sources of radiation that can be used in clinical imaging and to develop the understanding of the interactions that are likely to take place in the patient and detector.
2. To impart knowledge and understanding on the detectors commonly used in X-ray and gamma ray imaging.
3. To impart knowledge on the more recently developed sensors that may in the future find applications.
4. To impart knowledge on systems those are used in gamma ray imaging.
5. To develop understanding in how image contrast can be improved in X-ray imaging.
6. To develop skills in simple calculations that deal with contrast in X-ray imaging.

7. To develop understanding of the parameters used to describe images.

Course Contents:

INTRODUCTION

Radiation, Background Radiations, Natural Background Radiations, Cosmic radiations, Terrestrial Radiation, Human Caused Background Radiation, Ionization Radiation, Non Ionizing Radiation, Interaction of Radiation with matter, Biological Effects of radiation, Effects of Radiations used in Medical, Uses of ionizing radiation, Biological and medical applications of ionizing radiation, Radiation hazards and methods of control.

X-RAYS AND EFFECTS

Introduction of X-rays, Discovery of X-rays, Production of X-rays, Characteristics of X-rays, Application of X-rays (Engineering, Radiology (medical), Environment, Medicine), Medical Uses of X-rays, Harmful Effects of Radiation, CAT scanning.

MONITORING OF RADIATIONs

Detectors, Active Detectors, Passive Detectors, Solid State Nuclear Tracked Detectors (SSNTDs), Ionization Chamber, Semiconductor Dosimeter, Film Badges, Geiger Muller Counter (G.M Counter), Scintillation Counters, Thermo luminescent Dosimeter.

CLINICAL DOSIMETRY

Thermoluminscent Dosimeter, General Requirements for TLD Materials, Advantages and disadvantages of thermoluminescent dosimeter, Application of TLDs, Types of TLDs, Calcium fluoride TLDs, Lithium Fluoride TLDs, Personal dosimetry.

MEDICAL APPLICATION AND DOSE MEASUREMENTS,

Introduction of Dose measurement, Types of doses, units of dose measurements, Dose measurement in diagnostic X-rays and therapeutic X-rays, safety of X-rays, Interaction of X-photons with patients, radiographic contrast. Film as an X-ray image receptor. Digital image receptors. Scatter reduction. Image resolution. Image intensifiers. Equipment used for radiodiagnosis, conventional radiographic, dental, fluoroscopic, and X-ray CT. Computed radiography and Quality assurance of X-ray equipment.

TLDs READER SYSTEM

TLD Decoders(Reader), Calibration and Dose Verification, Annealing procedure of TLDs, Heating the Dosimeter, Photomultiplier Tube PMT, Pre-Operational Checks of thermoluminscent reader, Stability Check of thermoluminscent Reader.

RADIATION DECTECTION, PROTECTION AND INSTUMENTATION

Basic concepts of radioactivity, Principles of radiation detectors and their common properties, Radiation spectroscopy, Nuclear electronics, Various types of dosimeters, Basic concept of dosimetry, Dose calibrator, Collimation of radiation; Radiation protection standards, Basic principles for control of external and internal exposures and absorbed dose estimation, Protection against radiation from brachytherapy sources, Nuclear regulatory commission regulations, Health Physics instrumentation personal dosimetry, Early medical treatment of radiation injuries, Radioactive waste management in hospitals, Quality control and quality assurance of radiotherapy instrumentation.

Books Recommended

1. John R. Cameron, Medical Physics, John Willy and sons (1997)
2. William J. Price, Nuclear Radiation and Detection , McGraw Hill New York (1964)
3. J.R Albright, Atomic and nuclear physic , 2nd edition, McGraw Hill New York, (1993)
4. John R. Lamarsh, Introduction to Nuclear Engineering, Third Edition, Prentice Hall (2001),
5. Herman Cember, Introduction to Health Physics, Third Edition, McGraw-Hill Inc. (2003).

6. Ionizing Radiations (Medical Exposure) Regulations [IR (ME) R], 2000.

PHY-6809: Experimental Plasma Physics Credit Hrs. 3(3-0)

Course Objectives

This course provides Basic concepts and experimental techniques used to measure the properties and behavior of gaseous and solid-state plasmas. Experimental techniques include probe measurements of plasma parameters, microwave resonances, electron scattering, architecture of glow discharges, and determination of plasma temperature using atomic physics effects. The goals of this course are:

1. To provide the students with an understanding of plasma generation techniques.
2. To provide an understanding of the optical emission and probe diagnostic techniques used to characterize plasma.

Course Contents:

PLASMA GENERATION

Energy storage and transfer for high-temperature plasma generation and current drive techniques. Z-pinch, θ-pinch, and plasma focus devices. Cold plasma generation, characteristics of DC glow discharge, RF discharges and cold plasma reactors.

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, Time-resolved and time-integrated neutron measurement.

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. J. Reece Roth, Industrial Plasma Engineering, Institute of Physics Publishing Bristol (2000).
2. I. H. Hutchinson, Principles of Plasma Diagnostics, Cambridge University Press New York (1999).
3. A. H. Siedle and L. Adams, Handbook of Radiation Effects, Oxford University Press (2002).
4. F. F. Chen and J. P. Chang, Kluwer, Principles of Plasma Processing, Academic/ Plenum Publishers New York (2003).
5. H.ans R. Griem, Principles of Plasma Spectroscopy, Cambridge University Press (1997).
6. J. A. Bittencourt. Pergamon, Fundamentals of Plasma Physics, Press Oxford (1995).
7. Orlando Auciello and Daniel L. Flamm, Plasma Diagnostics, Academic Press Boston (1989).
8. John Wesson, Tokamaks, Clarendon Press Oxford (2004).

PHY-6810: Introduction to Particle Physics Credit Hrs. 3(3-0)

Course Objectives:

The course objectives for an "Introduction to Particle Physics" aim to provide students with a foundational understanding of the fundamental particles that make up the universe, their interactions, and the theoretical frameworks used to explain their behavior.

Course Contents:

Ingredients of the Standard Model, Quarks and leptons, Mesons and baryons, Exchange of virtual particles, Strong, electromagnetic and weak interactions, Relativistic kinematics, Invariant mass, thresholds and decays, Conservation laws, Angular momentum, Baryon number, lepton number, Strangeness, Isospin, Parity, charge conjugation and CP, The quark model, Super multiplets, Resonances, formation, production and decay, Heavy quarks, charm, bottom and top, Experimental evidence for quarks, Color, confinement and experimental value, Weak interactions, Parity violation, Helicity, CP violation, K^0 and B^0 systems, The Standard Model and beyond, Quark-lepton generations, Neutrino oscillations, The Higgs boson, Grand Unified Theories, Supersymmetry.

Recommended Books

1. Martin, B. R. & Shaw, G. Particle Physics John Wiley & Sons Inc., 1997.
2. Perkins, D.H. Introduction to High Energy Physics Cambridge University Press, 2000.

PHY-6811: Computer Simulation Credit Hours: 3(2-1)

Course Objective:

Computer Simulation focuses on the development, implementation, and application of computer-oriented simulation techniques and methods to modern research problems in natural sciences and engineering. Students will use various programming tools to explore a range of scientific problems, particularly those related to materials.

Course Contents

Introduction to Linux operating system, fundamental commands in Linux, analysis of data in terminal, Introduction to computer hardware and software, Introduction to programming languages, Development of scripts, shell scripts, python scripts, visualization, plotting and analysis of data using scripts, Flow chart of simulations, parallel computing and high-performance computing, Numerical techniques, application of computer simulations in condensed matter physics, introduction of VASP simulation package, flow chart of simulations in VASP, calculations of total energy, electronic structure and magnetic properties of crystalline solids.

Recommend Books

1. Alexander K Hartmann, Big Practical Guide to Computer Simulations, 2nd Edition, 2015, Word Scientific.
2. Juan Manuel Durán, Computer Simulations in Science and Engineering, 1st Edition, 2018, Springer Cham