FIRST SEMESTER

PY6101: ATOMIC, MOLECULAR & LASER PHYSICS [2 1 0 3]

An overview of atomic spectra, L-S and J-J coupling approximation, spectral terms of atoms with two or more non-equivalent optical electrons, Lande`s interval Rule, Normal and inverted multiplets, order of terms and fine structure levels, selection rules for multi electron atoms in LS coupling and J-J coupling. Spectra of Alkali Elements: Spectra of alkaline earth elements, spectra of elements with "P" configuration, spectra of elements with unfilled d & f – shells. Normal and specific mass shifts, Anomalous Zeeman effect, Paschen-Back and Stark Effects, Applications of Resonance Spectroscopy: ESR. Molecular Spectra: Electronic, Rotational & vibrational spectra for diatomic molecules, Frank– Condon principle, Dissociation energy & products, Raman Spectroscopy. Atoms in External Fields (Electric & Magnetic): Zeeman Effect, Stark effect, illustration for H-atom & series limit, theory for nonhydrogenic atoms- He & Alkali metals. Spectrographs: UV- Vis- IR region and applications. Laser Physics: Laser light and its characteristics, Threshold condition, 4-level Laser system, CW operation of Laser, population inversion & photon number in the cavity, output coupling of Laser power, Optical resonators, cavity modes, mode selection, pulsed operation of Laser, Q-switching and mode locking, Ruby, CO2, Dye & Semiconductor diode Laser. Holography: Recording and reconstruction of reflection hologram, simple applications.

References:

1. H. E. White, Atomic Spectra, Tata McGraw-Hill, 1999.
2. E. U. Condon and G. H. Shortley, The Theory of Atomic Spectra, Cambridge University Press, 1992.
3. G. Hertzberg, Atomic Spectra and Atomic Structure, Dover Publication, New York, 2010.
4. C. N. Banwell and E. M. Mccash, Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill, 2002.
5. G. Aruldas, Molecular structure and spectroscopy, PHI, New Delhi, 2007.
6. B. B. Laud, Laser and Non-linear Optics, New Age International Publisher, 2011.

PY6102: MATHEMATICAL PHYSICS [3 1 0 4]

Fourier analysis and transforms: Integral and Fourier Transformations: Fourier series and integral, Complex form of Fourier series and integral, Fourier transforms (sin and cosine), Convolution theorem and Parseval's identity, Laplace and Inverse Laplace transforms, Heaviside expansion formula. Curvilinear Coordinates and Matrices: Generalized orthogonal coordinates, elements of curvilinear coordinates, transformation of coordinates, expression for arc length, volume element, Gradient, divergence and curl, Laplacian in Cartesian, spherical polar and cylindrical coordinates, Matrix representation of linear operators, Hermitian and unitary solution of system of linear equations, coordinate transformation. Complex Variables and Integral Transforms: Cauchy Riemann conditions, Contour integrals, Cauchy integral formula and theorem, Taylor and Laurentz series, Singularities and residues, The Cauchy's residue theorem and principle value. Calculus of variations Group theory and symmetry in physics, Tensor algebra, quotient law, Groups, Homomorphism and Isomorphism, reducible and irreducible representation and their decomposition, Schur's lemmas, orthogonality theorem, Construction of representations, Representation of groups, Lie groups and algebra, Three dimensional rotation group SO(3), SU(2) and SU(3) groups. Special Functions: Delta function, beta, gamma and Bessel functions, solution of Bessel's equation, Neumann and Hankel functions, orthogonality of Bessel functions, Spherical Bessel functions, Legendre polynomials solution of Legendre equation, generating function and recurrence relations, orthogonality property of Legendre polynomials, associated Legendre polynomials and spherical harmonics. Solution of Laguerre's equation, Laguerre and associated Laguerre polynomials, Solution of Hermite equation, Hermite polynomials, generating functions and recurrence relations.

References:

1. G. Arfken, Mathematical Methods for Physics, Academic press, 2012.
2. E. Kreyzing, Advanced Engineering Mathematics, John Wiley and Sons, 2011.
3. A. K. Ghatak, I. C. Goyal, S. J. Chuja, Mathematical Physics, Macmillan, 2000.
4. A. W. Joshi, Matrices and Tensors for Physicists, New Age International, 1995.
5. W. W. Bell, Special Functions for Scientists and Engineers, Dover, 2004
6. J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw-Hill, 2009.

PY6103: QUANTUM MECHANICS [3 1 0 4]

Overview of Quantum Mechanics: Matrix Formulation of Quantum Mechanics: Hermitian and unitary Matrices, Transformation and diagonalization of Matrices, Function of Matricies and matrices of infinite rank, Vector representation of states, transformation of Hamiltonian with unitary matrix, representation of an operator, Hilbert space, Dirac bra and ket notation, projection operators, Schrodinger, Heisenberg and interaction pictures, Relationship between Poisson brackets and commutation relations, Matrix theory of Harmonic oscillator. Identical Particles: Permutation symmetry, symmetrization postulates, Slater determinant, Addition of angular momentum and Clebsch-Gordon Coefficient. Symmetry in Quantum Mechanics: Unitary operators for space and time translations, Symmetry and degeneracy, Angular momentum, Commutation relations, eigenvalue spectrum, angular momentum matrices of J +, J-, Jz, Pauli spin matrices, Addition of angular momentaMatrix elements for rotated state, irreducible tensor operator, Wigner-Eckart theorem, Rotation matrices and group aspects, Space inversion and time reversal, parity operator and anti-linear operator, Dynamical symmetry of harmonic oscillator. Applications: non-relativistic Hamiltonian for an electron with spin included, C.G. coefficients of addition for j =1/2, 1/2; 1/2, 1; 1, 1. Scattering Theory:

Differential and total Scattering cross-sections laws, partial wave analysis and application to simple cases; Green Function, Born approximation validity and simple applications.

References:

1. A K. Ghatak and S. Lokanathan, Quantum Mechanics, Kluwer Academic, 2004.
2. J. L. Powell and B. Crassemann, Quantum Mechanics, Dover, 2015.
3. J. J. Sakurai, Modern Quantum Mechanics, Pearson, 2014.
4. P. M. Mathews and K. Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, 2010.

PY6104: ELECTRONICS [3 1 0 4]

Network Analysis: Review of network analysis and theorems, Thevenin's theorem, Norton's Theorem, Superposition Theorem, Maximum power transfer Theorem. Semiconductor Devices and Circuits: Characteristics of a p-n junction, Clipping and clamping circuits, Response of RC-differentiator and integrator circuits for sine, square and ramp wave signals, BJT, JFET and MOSFET devices, Voltage divider bias, Small signal analysis of BJT and FET amplifiers in CE/CS configuration, Comparison of CE/CS configuration with CB/CG and CC/CD configurations, Frequency response of BJT amplifier, UJT characteristics and its use in a relaxation oscillator, SCR characteristics and its use in ac power control. Operational Amplifiers and Circuits: BJT differential amplifier, Operational amplifier, voltage/current feedback concepts (series & parallel), Inverting and noninverting configurations, Basic applications of Opamps, comparator and Schmitt trigger, IC555 timer, monostable and a stable multivibrators, Crystal oscillator using opamp, Voltage regulator using series transistor and opamp with current limiting facility, Three terminal IC regulators, Switch mode power supply (block diagram). Digital Electronics: Review of number systems, logic gates, latches and flip-flops, Simplification of logic functions by Karnaugh maps, Tristate devices, Decoders and encoders, Multiplexers and demultiplexers with applications, Synchronous counter design, Digital to analog conversion with R/2R network, Analog to digital conversion using flash technique.

References:

1. W. H. Hayt, J. E. Kemmerly and S. M. Durbin, Engineering Circuit Analysis, McGraw- Hill, 2002.
2. R. L. Boylestad, Introductory Circuit Analysis, Prentice Hall, 1997.
3. R. L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory, Prentice Hall, 2002.
4. T. L. Floyd, Electronic Devices, Pearson, 2001.
5. R. A. Gayakwad, Opamps and Linear Integrated Circuits, PHI, 1993.

PY6105: CLASSICAL MECHANICS [3 1 0 4]

Lagrangian Formalism: Constraints, holonomic and non-holonomic constraints, D'Alembert's Principle and Lagrange's Equation, velocity dependent potentials, simple applications of Lagrangian formulation, Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle, Extension of Hamilton's Principle for non-conservative and non-holonomic systems, Method of Lagrange's multipliers, Conservation theorems and Symmetry Properties, Noether's theorem, Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space. Hamiltonian's Formalism: Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical Equation from Hamilton's variational principle, Principle of least action. Canonical Transformation: Integral invariant of Poincare, Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation, Infinitesimal contact transformation and generators of symmetry, Liouvilee's theorem, Hamilton-Jacobi equation and its application, Action angle variable adiabatic invariance of action variable, The Kepler's problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications, Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body. Perturbation theory and small parameter expansions, Nonlinear dynamics and chaotic systems.

References:

1. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, Perason, 2014.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.
3. L.D. Landau and E.M. Lifshitz, Mechanics, Butterworth-Heinemann, 2000.
4. David Morin, Introduction to Classical Mechanics with problems and solutions, Cambridge University Press, 2009.

PY6130: ELECTRONICS LAB [0 0 6 3]

Design of a regulated power supply, Design of a common emitter transistor amplifier, Design of a stable multivibrator, Design of monostable and Design of Bistable multivibrators, SCR Characteristics, Wein bridge Oscillator, Phase shift oscillator, Zener diode charecteristics and voltage regulation, FET and MOSFET characteristics and application as an amplifier. LOGIC GATES: TTL, NAND and NOR gates. Digital II: Combinational Logic, FLIP-FLOPS, Operational Amplifiers (741), Differential amplifier, Experiment with Microprocessor kit.

References:

1. D. Chattopadhyay and P. C. Rakshit, Practical Physics, New Central Book Agency (p) Ltd., London, 2012.
2. W. H. Hayt, J. E. Kemmerly and S. M. Durbin, Engineering Circuit Analysis, McGraw-Hill, 2002.

3. H. Singh and P. S. Hemne, Practical physics, S. Chand & Company LTD., 2011.
4. T. L. Floyd, Digital Fundamentals, Pearson, 2002.

SECOND SEMESTER

PY6201: SOLID STATE PHYSICS [3 1 0 4]

Crystal Structure and Symmetry: Crystal lattice and unit cells, Bravais lattices, Crystallographic symmetry operations, Miller indices and crystal planes. X-ray diffraction and crystallography techniques: Reciprocal lattices and Brillouin zones, Ewald Sphere, experimental diffraction techniques indexing of powder photographs and lattice parameter determination, atomic scattering factor and structure factor. Thermal and Electrical Properties: Lattice Vibrations and Thermal Properties: Vibrations of linear, mono and diatomic lattices, acoustical and optical phonons, specific heat of solids, Einstein and Debye theory of specific heat. Drude Model, Electrical, and thermal conductivity, Wiedemann–Franz Law, Sommerfeld theory of Metals, Bloch theorem, Kronig-Penny model, effective mass of electrons, free electron model, tight binding method. Semiconductors, Direct and Indirect band. Semiconductors: Hall-effect, recombination mechanism, optical transitions and Schockely-Read theory, excitons, photoconductivity, photo-Luminescence, Defects. Magnetic Properties of Solids: Quantum theories of diamagnetism and paramagnetism, Paramagnetic susceptibility of conduction electrons, Weiss molecular fields theory of ferromagnetism, Exchange interaction, Neel model of anti-ferromagnetism and ferrimagnetism. Origin of magnetic domain and domain walls, Collective magnetic excitations, Spin waves. Superconductivity: Macroscopic properties, Meissner effect, Isotope effect, Manifestations of energy gap, London theory, flux quantization, Josephson tunnelling. BCS Theory.

References:

1. L. Azaroff, Introduction to Solids, McGraw Hill, 2001.
2. C. Kittle, Introduction to Solid State Physics, Wiley-India Edition, 2012.
3. N. W. Ascroft, N. D. Mermin, Solid State Physics; Harcourt Asia, 2003.
4. M. A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa, 2015.
5. M. Ali. Omar, Elementary Solid State Physics: principles and applications, Pearson, 2002.
6. G.H. Stout and L.H. Jensen, X-Ray Structure Determination: A practical Guide, Wiley, 1992.
7. P. M. Chaikin and T. C. Lubensky, Principals of Condensed Mater Physics, Cambridge, 2000.
8. A. R. Verma and O. N. Srivastava, Crystallography for Solid State Physics, New Age International, 1991.

PY6202: NUCLEAR AND PARTICLE PHYSICS [3 1 0 4]

Introduction to Nuclear properties, Nuclear Interaction: Bound State of two nucleons, Theory of Ground State of two nucleons, Nucleon-nucleon scatterings (n-p & p-p) at Low energies (<10MeV), Scattering Length, Effective range theory in n-p and p-p scattering, Spin dependence of nuclear forces, Scattering of Neutrons by ortho- and para hydrogen molecule. Nuclear Reactions: Direct and Compound nuclear reaction mechanisms, Scattering and reactor cross sections by partial wave analysis, Bohr's theory of compound nucleus, Resonance reaction and Briet-Winger one level formula, Bohr-Wheeler theory of fission & Nuclear Reactors. Nuclear Models: Shell model, Experimental evidence for shell effects and magic numbers, Shell model spin orbit coupling, Schmidts lines and prediction of angular momentum and parity of nuclear ground states, Collective model of Bohr and Mottelson – rotational States and Vibrational levels, Nilsson Model. Particle Physics: Elementary Particles and their classifications, conservation laws, parity conservation and violation, conservation of isotopic spin, Gell-Mann Nishijima scheme, Charge conjugation and time reversal, CP violation and CPT theorem, Strong, Weak and electromagnetic interactions, coupling constants, decay life times and cross sections. Nuclear Applications: Nuclear medicine and medical imaging Radiation therapy, Nuclear power and reactor physics, Nuclear waste management, Nuclear forensics and safeguards, Environmental applications of nuclear techniques.

References:

1. R. R. Roy and B.P. Nigam., Nuclear Physics: theory and experiment, New Age International, 1996.
2. I. Kaplan, Nuclear Physics, Narosa, 2002.
3. B. L. Cohen, Concepts of Nuclear Physics, Mc Graw-Hill, 1971.
4. E. Fermi, Nuclear Physics, University of Chicago Press Books, 1950.
5. A. Bohr and B.R. Mottelson, Nuclear Structure, World Scientific, 1998.
6. R.D. Evans, Atomic Nucleus, Krieger Publishing Co., 1982.

MA6205: RESEARCH METHODOLOGY & TECHNICAL WRITING [2 1 0 3]

Foundations of Research: Meaning, objectives, motivation, utility, empiricism, deductive and inductive theory, characteristics of scientific method, understanding the language of research. Research Process: Problem identification & formulation, research question, investigation question, measurement issues, hypothesis, qualities of a good hypothesis, types of hypothesis. Research Design: Concept and importance in research, features of a good research design, exploratory research design, descriptive research designs, experimental research design. Types of Data: Classification of data, uses, advantages, disadvantages, sources. Measurement: Concept of measurement, problems in measurement in research, validity and reliability, levels of measurement. Statistical Techniques and Tools: Introduction of statistics, functions, limitations, graphical representation, measures of central tendency, measure of dispersion, skewness, kurtosis, correlation, regression, tests of significance based on t, F, Chi-square, Z and ANOVA test. Paper Writing: Layout of a research paper, Scopus/Web of Science journals, impact factor of journals, when and where to publish, ethical issues related to publishing, plagiarism and self-plagiarism. Introduction to LATEX and MATLAB.

References:

1. C.R. Kothari, Research Methodology Methods & Techniques, New Age International Publishers, Reprint 2008.
2. R. Singh, Research Methodology, Saga Publication, 4^{th} edition, 2014.

3. J. Anderson and M. Poole, Thesis and Assignment Writing, Wiley India 4th edition, 2011.
4. Mukul Gupta and Deepa Gupta, Research Methodology, PHI Learning Private Ltd., New Delhi, 2011.
5. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi, 1999.

PY6203: ELECTRODYNAMICS [2 1 0 3]

Electrostatics: Review of electrostatics, Poisson and-Laplace equations, Green's Theorem, Uniqueness of the solution with Dirichlet or Neumann Boundary conditions, Electrostatic Boundary value problem with Green's Function, Electrostatic potential energy and energy density, capacitance. Boundary-Value Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere point charge in the presence of a charge insulated conducting sphere, Point charge near a 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 potential, orthogonal functions and expansion. Magnetostatics: Review of magnetostatics, Boundary conditions on B and H, Methods of solving Boundary-value problems in magnetostatics, Uniformly magnetized sphere, Magnetized sphere in an external field, Permanent magnets, Magnetic shielding, spherical shell of permeable material in an uniform field. Dielectrics: Multipole expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media, Boundary value problems with dielectrics, Electro-static energy in dielectric media. Maxwell's equations and Conservation Laws: Energy in a magnetic field, Vector and Scalar potentials, Gauge transformations, Lorentz gauge, Coulomb gauge, Green functions for the wave equation, Derivation of the equations of Macroscopic Electromagnetism, Poyntings theorem and conservations of energy and momentum for a system of charged particles, Conservation laws for macroscopic media. Special Topics: Relativistic electrodynamics, Covariant formulation of electromagnetism, Electromagnetic fields in matter, Electromagnetic wave propagation in plasmas, Quantum electrodynamics (QED), Applications of electrodynamics (e.g., antennas, optical devices).

References:

1. J. D. Jackson, Classical Electrodynamics, Wiley, 2007.
2. D. J. Griffiths, Introduction to Electrodynamics, Pearson, 2015.
3. K. H. Panofsky and M. Philips, Classical Electricity and Magnetism, Addison- Wesley Publishing Co., 2006.
4. L. D. Landau and E.M. Lifshitz, The Classical Theory of Field, Butterworth-Heinemann, 1987.
5. J.R. Reitz, F.J. Milford and R.W. Cristy, Foundations of Electromagnetic Theory, Addison Wesley, 1992.

PY6230: SOLID STATE PHYSICS LAB [0 0 6 3]

Determinations of Lande's 'g' factor for DPPH (diphenyl-picrylhydrazyl) using electron spin resonance (ESR) spectrometer, Determination of Fermi energy of metals, p-n Junction Capacitance, Determination of transition temperature in ferrites, Magnetic susceptibility experiment using Quinke's tube, Calibration of silicon resistance thermometer and measurement of temperature from 77K to room temperature, measurement of magneto resistance, Determination of transition temperature in ferroelectrics, Dispersion relation and cutoff frequency in the case of a mono-atomic lattice using lattice dynamics kit, Dispersion relation, acoustical mode and optical mode of a diatomic lattice using lattice dynamics kit.

References:

1. C. Kittle, Introduction to Solid State Physics, Wiley-India Edition, 2012.
2. M.A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa publication, 2015.
3. M. Ali. Omar, Elementary Solid State Physics: principles and applications, Pearson publication, 2002
4. G.H. Stout and L.H. Jensen, X-Ray Structure Determination: A practical Guide, Wiley, 1992.
5. P. M. Chaikin and T.C. Lubensky, Principals of Condensed Mater Physics, Cambridge publication, 2000.

PY6231: NUCLEAR PHYSICS LAB [0 0 6 3]

Introduction to nuclear radiation, safety parameters and handling of radioactive sources. GM Counter Characteristics and operating voltage, Dead time of GM tube by single source method and by double source method, Range of Β particles using GM counter, Range and energy of Alpha particles by GM method, Inverse square law for Gamma radiation using GM Counter, Linear attenuation coefficient for γ- rays (GM), Absorption of gamma rays by lead-mass absorption coefficient and half value thickness of the absorber, Characteristics of scintillation counter, To determine the operating voltage of a –photomultiplier tube and to find the Photo-peak efficiency of a NaI (Tl) crystal of given dimensions for gamma rays of different energies, To determine the energy resolution of a NaI (Tl) detector and to show that it is independent of the again of the amplifier. Energy Calibration using scintillator detectors.

References:

1. R.R. Roy and B.P. Nigam., Nuclear Physics: theory and experiment, New Age International, 1996.
2. I Kaplan, Nuclear Physics, Narosa, 2002.
3. E. Fermi, Nuclear Physics, University of Chicago Press Books, 1950.
4. R.D. Evans, Atomic Nucleus, Krieger Publishing Co. 1982.

PY6232: SPECTROSCOPY LAB [0 0 4 2]

Hydrogen spectra - determination of Rydberg constant, Absorption spectrum of iodine- determination of dissociation energy of I_2, Study of the arc spectra of iron, copper, Zinc and brass, Identification of elements by spectroscopic method, Study of normal Zeeman effect, Measurements of wavelength of He-Ne laser light using ruler, Hyperfine structure of spectral lines using Fabry-Perot etalon/Lummer-Gehrcke plate, GM counter characteristics, Analysis of the given vibration-rotation spectrum, Interpretation of a Raman and IR spectra of simple triatomic molecules, Dissociation energy of diatomic molecules- comparison of different Spectroscopic methods, Analyses and, Identification of substances using XRD-patterns using ASTM cards, Identification of elements from stellar spectra, Gaussian power distribution law using lasers, Determination of Curie temperature, Compton spectrometer using microwave and " Tennis ball " model.

References:
1. H. E. White, Atomic Spectra, Tata McGraw-Hill, 1999.
2. C. N. Banwell and E. M. Mccash, Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill, 2002.
3. E. U. Condon and G. H. Shortley, The Theory of Atomic Spectra, Cambridge University Press, 1992.
4. G. Hertzberg, Atomic Spectra and Atomic Structure, Dover Publication, New York, 2010.

THIRD SEMESTER

PY7101: STATISTICAL MECHANICS [3 1 0 4]

Review of Thermodynamics: Foundations of statistical mechanics, specification of states of a system-the microstate and the macro state, contact between statistics and thermodynamics, the free energy, the thermodynamics of gases (evaluation of Boltzmann partition function and classical partition function), classical ideal gas, entropy of mixing and Gibb's paradox, the semi-classical perfect gas. Ensembles: Microcanonical ensemble, phase space, trajectories and density of states, Liouville's theorem, canonical ensemble thermodynamic properties of the canonical ensemble, evaluation of the total partition function, partition function in the presence of interactions fluctuation of the assembly energy in a canonical ensemble, grand canonical ensemble, the grand partition function and its evaluation, , the chemical potentials in the equilibrium state. Different Statistics: Maxwell-Boltzmann distribution, determination of undetermined multipliers ß and a, equipartition of energy, the Einstein Diffusion equation, Bose-Einstein statistics, the Bose- Einstein gas, Bose-Einstein condensation, Fermi-Dirac statistics, the Fermi-Dirac gas, the electron gas. Expansion of Gas: Cluster expansion for a classical gas, virial expansion of the equation of state, evaluation of the virial coefficients the Ising model, equivalence of the Ising model to other models, spontaneous magnetization, the Bragg-Williams approximation, the Bethe-Peierls approximation. Phase Transitions: Landau theory of phase transition, critical exponents, scaling hypothesis for the thermodynamic functions, Fluctuations, time-dependent, correlation functions, fluctuations and thermodynamic properties. Brownian motion, Langevin theory, fluctuation-dissipation theorem, the Fokker-Planck equation.

References:
1. B. K. Agrawal, Statistical Mechanics, Wiley, 1998.
2. R.K. Pathria, Statistical Mechanics, Academic Press, 2011.
3. F. Reif, Statistical and Thermal Physics, Waveland Press, 2010.
4. K. Huang, Statistical Mechanics, Wiley, 2008.
5. L. D. Landau and E. M. Lifshitz, Statistical Physics, Elsevier, 2008.

PY7102: ADVANCED QUANTUM MECHANICS [3 1 0 4]

Perturbation Theory: Time independent (degenerate and non-degenerate) perturbation theory and its applications, time dependent perturbation theory, transition amplitude, transition probability, Fermi's Golden rule. Approximation Methods: Variation methods and its applications, WKB approximation and its applications. Scattering Theory: Scattering in laboratory and centre of mass frame of references, Partial wave analysis, Phase shifts, Applications of scattering and optical theorem, Born approximation and its applications, exchange operator, symmetric and anti-symmetric wave function, collision of identical particles and their scattering amplitude. Klein-Gordon Equation: Klein-Gordon equation, Plane wave solutions, probability current density and equation of continuity, difficulties due to existence of negative energy states, relativistic expression for probability density, Klein-Gordon equation in electromagnetic field and its applications. Dirac Equation: Derivation of Dirac equation, ß-matrices, their anti-commutation relations and their representations, Plane wave solutions of Dirac Equation (Positive energy and Negative energy solutions), Existence of electron spin for a Dirac particle, Covariance of Dirac Equation, γ-matrices and their properties. Heisenberg Representation in Dirac Theory: Dirac operators in the Heisenberg representation, spin of Dirac particle, Velocity in Dirac theory, Zitterbewegung and negative energy solutions, Presence of negative energy components, Hole theory and charge conjugation. Relativistic Dirac Equation: Dirac Equation, relativistic Hamiltonian, probability density, expectation values, Dirac matrices, and their properties, non-relativistic limit of Dirac equation, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, negative energy sea. Field Quantization: The procedure for quantization of fields, quantization of non-relativistic Schrodinger equation, second quantization, N-representation creation and annihilation operators.

References:
1. L.I. Schifff, Quantum Mechanics, McGraw-Hill, 2017.
2. P. M. Mathews and K. Venkatesan, A Text Book of Quantum Mechanics, Tata McGraw Hill, 2010.
3. J. J. Sakurai, Modern Quantum Mechanics, Pearson, 2014.
4. N. Zettili, Quantum Mechanics: Concepts & Applications, Wiley India, 2017.

PY7103: NUMERICAL METHODS AND PROGRAMMING [3 1 0 4]

Interpolation: Lagrange's Newton interpolation method, Least square line fitting, Numerical differentiation, Numerical Integration (Gaussian Quadrature method, Newton-cotes Integration formula, Trapezoidal rule and Simpson's and Romberg rules) Numerical methods for ordinary differential equations, Euler's method & Runge-Kutta method (second & fourth order). Solution of Simultaneous Algebraic Equations: Back substitution Gauss Elimination method, Gauss-Jordan Elimination method, Pivoting, Jacobi methods & Gauss-Seidel iterative methods Comparison of direct and iterative methods, Root-finding Algorithms, Bisection method, successive bisection method, method of false position, Newton-Raphason method, Secant method, method of Successive approximations. Introduction to Programming in C++: Then input and output operator, comments, Data types, Variables, objects and their declarations, keywords and identifiers chained assignments Integer types, simple arithmetic operators, operator precedence and associativity, the increment and decrement operators, compound assignment expressions, In tiger overflow and underflow, simple programs. Conditional Statements and Integer Types: The if statement, the if-else statement, Relational operators, Compound Statements, Compound Conditions Nested Conditions, the Switch Statement, Enumeration types. Iteration and Floating Types: The while statement, the do-while statement, for statement break statement, continue statement, the go to statement. Function & Arrays: Function declaration & definitions, local variables & functions, void functions, passing by reference and passing by value, passing by constant reference, inline functions, overloading, main ( ), exit ( ) functions, Array declaration and initializing, processing Arrays, passing an Array to a function, the Linear search and Bubble sort algorithm, binary search algorithm, using arrays with enumeration types, Multidimensional Arrays. Pointers and References: Pointers declaration, pointer operator, address operator, pointer arithmetic's References, Derived types, Arrays & pointers, the new operator, the delete operator, dynamic arrays, Arrays of pointers and pointers to Arrays, Pointers to Pointers. Pointers functions, call by value, call by References. Classes: Introduction, class declaration, constructor, constructor initialization, Private member function, class constructor, copy constructor, Pointers to object. Stream I/O: Stream classes, the ios class, ios format flags, ios state variables, the istream & o stream classes, unformatted input functions.

References:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall, 2006.
2. W. H. Press, A. S. Teukolskly, T. W. Vertterling, and P. B. Flannery, Numerical Recipes, Cambridge University Press, 2007.
3. R. L. Burden, J. D. Faires, Numerical Analysis, Cengage Learning, 2010.
4. R. Pratap, Getting started with MATLAB, Oxford University Press, 2010.
5. H. John, Programming in C++, McGraw-Hill, 2005.
6. J. R. Hubbard, Schaum's Outline Series, Programming in C++, McGraw-Hill, 1996.
7. R. Lafore, Object Oriented Programming in Turbo C++, SAMS Indiana 46240 USA, 2002.

PY7170: SEMINAR [0 0 4 2]

Weekly discussion on presentation topic selection, practice of presentation, monthly presentation for evaluation.

PY7130: COMPUTER LAB [0 0 4 2]

Least square fitting, Problems on numerical integrations by different methods (a) Integrating a given function using Trapezoidal rule, (b) Integrating a given function using Simpson's 1/3 rule, Programming on numerical solution of ordinary differential equations (a) using Euler's method, (b) using Runge-Kutta method, Programming on solution of nonlinear equations by various methods (a) Root within an interval using Bisection Method, (b) Root near a given point by Newton-Raphson Method, Programming on solutions of system of linear equations through (a) Jacobi iteration method, (b) Gauss Seidal method and method of relaxation, (a) Programming on interpolation methods. Finding the Interpolation value at a point, given a set of table points, using (a) Lagrange interpolation representation, (b) Newton interpolation representation, (c) Natural cubic spline interpolation, Problems on Monte Carlo Technique (a) Generation of random numbers, (b) Monte Carlo evaluation of integrals, (c) Monte – Carlo method – determination of the value of π using random numbers, Taylor series evaluation to find sin(x), cos(x), log(x) and exp(x).

References:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall, 2006.
2. R. L. Burden, J. D. Faires, Numerical Analysis, Cengage Learning, 2010.
3. R. Pratap, Getting started with MATLAB, Oxford university press, 2010.
4. R. Lafore, Object Oriented Programming in Turbo C++, SAMS Indiana 46240 USA, 2002.
5. H. John, Programming in C++ (Schaum S Outline Series), Mc-Graw Hill, 2005.

FOURTH SEMESTER

PY7270: MAJOR PROJECT [0 0 0 16]

Literature survey, selection of research topic, experimental/theoretical work, presentation for mid-terms evaluation, project report writing, presentation for end-term evaluation.

DISCIPLINE SPECIFIC ELECTIVES (DSE)

PY7140: FUNDAMENTALS OF NANOSCIENCE [3 1 0 4]

Emergence of Nanoscience: Timeline and Milestones, Overview of different nanomaterials available, Schrodinger equation, Electron confinement, Tunneling of a particle through potential barrier, Density of states (0D, 1D, 2D, 3D). Synthesis of Nanomaterials: "Top-Down" and "Bottom-Up" approaches of nanomaterial (nanoparticles, nanoclusters and quantum dots) synthesis: Top-down techniques: photolithography, optical lithography and electrochemical etching, Bottom-up techniques: self-assembly, self-assembled monolayers, Combination of Top-Down and Bottom-up techniques: PVD, sputter deposition, CVD electric arc deposition, Ion beam techniques, Novel physical chemistry related to nanoparticles such as colloids and clusters, Role of polymers in lithography resists. Characterization: X-ray diffraction, UV-Vis spectroscopy, Fourier Transform Infrared Spectroscopy, Fluorescence, Transmission electron microscope, Scanning electron microscope, Atomic force microscope, scanning tunneling microscope. Nanoelectronics: Metal, insulator and Semiconductors: classification, electrons and holes, transport properties, size and dimensionality effects, Quantum size effects in semiconductor quantum dots and nanowires, Introduction to single electron transistors (SETs): quantum dots, single electron effects, Coulomb blockade.

References:

1. C. P. Poole, Introduction to Nanotechnology, John Wiley & Sons, 2010.
2. H. S. Nalwa, Nanostructured Materials and nanotechnology, Academic Press, 2001.
3. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Application, Imperial College Press, 2004.
4. S. K. Kulkarni, Nanotechnology: Principles and Practices, Springer, 2007.

PY7141: RADIATION PHYSICS [3 1 0 4]

Interaction of ionizing radiation and particles with matter: Photoelectric absorption, Compton scattering and pair-production, Gamma ray attenuation, attenuation coefficients, absorber mass thickness, cross sections, Energy loss of charged particles through matter, Bethe block ionization formula, Range-Energy relation, Multiple coulomb scattering-p, ß-measurements, Bremsstrahlung and Cerenkov radiations Interaction-stopping power-energy loss characteristics, particle range-energy loss in thin absorbers, Scaling laws, Interaction of fast electrons, specific energy loss, Electron range and transmission curves. Interaction of neutrons, general properties, slows down interaction, fast neutron interaction, neutron cross sections, Radiation exposure: Absorbed dose, Kerma, exposure, activity, rate constants, Charged Particle Equilibrium (CPE), relationship between Kerma, absorbed dose and exposure under CPE; determination of exposure and air kerma. Semiconductor Detectors: Semiconductor properties, physics of semiconductor detectors, diffused junction, surface barrier and ion-implanted detectors, Si(Li), Ge(Li) and HPGe detectors, semiconductor detector spectrometer, SSNTD, TLD, Superheated drop detectors, Neutron detectors, Neutron detection from nuclear reactions, BF3 counters, 3He counters, fission detectors. Nuclear Measurements and techniques: Pulse height analysis of spectrum, activation method for neutron flux measurement, Recoil counters, neutron time of flight technique. Accelerators: Linear accelerators, Principle of orbital accelerators, Cyclotron, synchrocyclotron.

References:

1. G. F. Knoll, Radiation Detection and Measurement, John Wiley & Sons, 2017.
2. P. Marmier and E. Sheldon, Physics of Nuclear & Particles, Vol. I & II, Academic Press, 1970.
3. D. N. Ponearu and W. Greiner, Experimental Techniques in Nuclear Physics, Walter de Gruyter Berlin, 1997.
4. E. Persico, E. Ferrari and S. E. Segre, Principles of Particle Accelerators, 1968.