Course Structure of M. Sc. Programme(Physics)

SEMESTER-l

Code	Name	L T P C
PH501	Mathematical Physics-I	3 1 0 8
PH503	Classical Mechanics	3 1 0 8
PH505	Quantum Mechanics-I	3 1 0 8
PH507	Electrodynamics- I	3 1 0 8
PH509	Computer Programming	2 0 2 6
PH511	Physics Laboratory-I	0 0 6 6

Total credit = 44

SEMESTER-2

Code	Name	L T P C
PH502	Mathematical Physics-II	3 1 0 8
PH504	Electronics	3 1 0 8
PH506	Quantum Mechanics-II	3 1 0 8
PH508	Electrodynamics- II	3 1 0 8
PH510	Numerical Methods and Computational Physics	2 0 2 6
PH512	Physics Laboratory-II	0 0 6 6

Total credit = 44

SEMESTER-3

Code	Name	L T P C
PH601	Atomic and Molecular Physics	3 1 0 8
PH603	Solid State Physics	3 1 0 8
PH605	Nuclear and Particle Physics	3 1 0 8
PH607	Statistical Mechanics	3 1 0 8
PH611	Physics Laboratory-III	0 0 6 6
PH621	Project I	0 0 4 4

Total credit = 42

SEMESTER-4

Code	Name	L T P C
PH602	Instrumentation	2 0 3 7
PH622	Project II	0 0 12 12
PH6xx	Elective-I	3 1 0 8
PH6xx	Elective-II	3 1 0 8
PH6xx	Elective-III	3 1 0 8

Total credit = 43

Total Credit 173

PH501: Mathematical Physics – I[3 1 0 8]
Vector Analysis: Gradient, divergence, and curl. Gauss's theorem, Stoke's theorem, orthogonal curvilinear co-ordinate-spherical, polar and cylindrical co ordinates Tensor Analysis: Transformation of co ordinates, covariant and contravariant vectors, mixed tensor, Addition and Subtraction of tensor, Multiplication of tensor(outer product and inner product), contraction of tensor, symmetric tensor, anti symmetric tensor, quotient law, conjugate symmetric tensor, Christoffel's symbol, transformation of Christoffel's symbol,covariant differentiation of covariant vector, covariant differentiation of contravariant vector, covariant differentiation of tensor. Linear Algebra: Vector spaces, subspaces, bases and dimension, linear independence, spans, basis, linear transformation, image and kernel, rank and nullity, change of basis, similarity transformations, inner product spaces, orthonormal sets, Gram-Schmidt procedure, dual space, eigenvalues and eigenvectors, Hilbert space. Complex Analysis: Functions, limits, continuity, derivatives, Cauchy-Riemann equations, analytic and harmonic functions, contour, contour integrals, Cauchy-Goursat Theorem, Cauchy integral formula, Morera's theorem, convergence of series, Power series, Taylor series, Laurent series, singularities, Cauchy's residue theorem, applications of residue theorem, linear transformation, bilinear transformations, conformal mapping and applications.

Texts:

1. G. B. Arfken and H. J. Weber, Mathematical Methods for Physicists, Academic Press(1995)
2. T. Lawson, Linear Algebra, John Wiley & Sons (1996).
3. R. V. Churchill, Complex Variables and Applications. McGraw Hill (1990).

References:

1. M. L. Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons (1983).
2. A. W. Joshi, Matrices and Tensors in Physics, New Age (1995).
3. S. Lang, Introduction to Linear Algebra, Springer (1986).

PH502: Mathematical Physics – II[3 1 0 8]
Ordinary Differential Equations: First and second order equations with constant coefficients, series solution-Frobenius' method, Sturm-Liouville equations, Legendre, Bessel, Hermite, and Laguerre functions, Hypergeometric and confluent hypergeometric equations. Integral Transforms: Fourier and Laplace transforms, applications. Partial Differential Equations: Laplace equation, method of separation of variables, Green's function for Laplace equation, wave equations. Group Theory: Groups, subgroups, conjugacy classes, cosets, invariant subgroups, factor groups, homomorphism, kernels, continuous groups, Lie groups, generators, SO(2) and SO(3), SU(2). Group representations.

Texts:

1. G. B. Arfken and H. J. Weber, Mathematical Methods for Physicists, Academic Press (1994).
2. A. W. Joshi, Elements of Group Theory, New Age (1997).

References:

1. M. L. Boas, Mathematical Methods in Physical Sciences, John Wiley & Sons (1983).
2. E. A. Coddington, Introduction to Ordinary Differential Equations, Prentice Hall of India (1995).
3. I. Sneddon, Elements of Partial Differential Equations, McGraw Hill (1986).
4. M. Hamermesh, Group Theory and Its Applications to Physical Problems, Dover (1989).

PH503: Classical Mechanics[3 1 0 8]
Review: Newton's Laws and its applications.
Lagrangian Dynamics: Mechanics of a system of particles, constraints and generalized coordinates, D'Alembert's principle, Lagrange's equations, simple applications of lagrangian formulation. Variational calculus and Least Action principle. Central force problem: Equations of motion, orbits, Virial theorem, Kepler problem, scattering in a central force field, Transformation of scattering problem to laboratory frame. Rigid body motion: Orthogonal transformations, Euler angles, coriolis effect, angular momentum and kinetic energy, tensors and dyadic, inertia tensor, moment of inertia, method of solving rigid body problem and the Euler's equation of motion, applications, heavy symmetrical top. Hamiltonian formulation: Legendre transformations, Hamilton equations, cyclic coordinates and conservation theorems, principle of least action, canonical transformations, Poisson brackets and other canonical invariants, Hamilton-Jacobi theory, Action-angle variables. Small oscillations: Eigenvalue problem, frequencies of free vibrations and normal modes, forced vibrations, dissipation. Classical field theory: Lagrangian and Hamiltonian formulation of continuous system.

Texts

1. H. Goldstein, Classical Mechanics, 2nd Edition, Narosa, (2001).

References
1. L. Landau and E. Lifshitz, Mechanics, Oxford (1981).
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata-McGraw-Hill, 1991.

PH504: Electronics[3 1 0 8]

Analog electronics: Thevenin's and Norton's theorem; application to simple circuits. p-n junction devices, diode, transistors; Basic principle, biasing and characteristic of BJT, JFET and MOSFET. OP-AMP: Differential amplifiers; Op-Amp (741) circuits (amplifiers; scalar; summer; sub- tractor; comparator; logarithmic amplifiers; multiplier; divider; differentiator, integrator; analog computer; wave shapers; oscillators). Multivibrators: Astable, monostable and bistable MV using BJT and IC555. Digital electronics: Logic gates, half adder, full adder, comparators, decoders, multiplexers, demultiplexers, design of combinational circuits, sequential circuits, Flip-flops: RS flip-flop, JK flip-flop, JK master-slave flip-flops, T flip-flop, D flip-flop, synchronous and asynchronous counters, registers, A/D and D/A conversion, characteristics.

Texts:
1. A. Mottershead, Electronic Devices and Circuits, Prentice Hall of India (1993).
2. J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill (1995).
3. R. Gaekwad, Op-Amps and Linear Integrated Circuits, Prentice Hall of India (1995).
4. A. P. Malvino and D. P. Leach, Digital Principles and Applications, Tata McGraw Hill (1991).

PH505: Quantum Mechanics-I[3 1 0 8]

Origin of quantum Theory: Wave-Particle duality, matter waves, group velocity, phase velocity, uncertainty principle, wave packets. Basic postulates of quantum mechanics, concept of probability and probability current density, Schrodinger equation. Operators, eigenvalues and eigenfunctions. Simple potential problems: Particle in a box, potential steps, potential barriers, potential wells, bound states, delta function potential, linear harmonic oscillator, Hermite polynomials. Matrix formulation of Quantum Mechanics: Linear and matrix algebra, Dirac's bra and ket notation, matrix representations of vectors and operators, expectation values, different representations in quantum mechanics, parity operation. Matrix theory of harmonic oscillator. Theory of Angular Momentum: Spherical harmonics, eigenvalues for L^2, L_z, commutation relations, quantum numbers, degeneracies. Schrodinger Equation for Central Potential: Hydrogen atom, power series solution for the radial part, energy quantization, quantum numbers, Laguerre polynomials, 3-dimensional harmonic oscillator.

Texts
1. S. Gasiorowicz, Quantum Physics, John Wiley (Asia) (2000).
2. E. Merzbacher, Quantum Mechanics, John Wiley (Asia) (1999).

References
1. C. Cohen-Tannoudji, Quantum mechanics, John Wiley &sons, 2005
2. P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1995).
3. J.J Sakurai, Modern quantum mechanics, Pearson education, 2005
4. L. I. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
5. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, Longman (1993)

PH506: Quantum Mechanics-II[3 1 0 8]

Perturbation Theory: Non-degenerate and Degenerate Cases. applications: Zeeman and Stark effects. Induced electric dipole moment of Hydrogen Real Hydrogen Atom: Relativistic correction, spin-orbit coupling, anomalous Zeeman effect, hyperfine interaction, Helium atom, exclusion principle, exchange interaction. Schrodinger equation for a slowly varying potential, WKB approximation, turning points, connection formulae, derivation of Bohr-Sommerfeld quantization condition, applications of WKB. Time Dependent Perturbation Theory: Sinusoidal perturbation, Fermi's Golden Rule, special topics in radiation theory, semi-classical treatment of interaction of radiation with matter, Einstein's coefficients, spontaneous and stimulated emission and absorption, application to lasers. Scattering Theory: Born Approximation, scattering cross section, Greens functions. Scattering for different kinds of potentials, applications. Relativistic Invariance, Klein-Gordon equation, Dirac equation, non relativistic limit of Dirac equation.

Texts:
1. S. Gasiorowicz, Quantum Physics, John Wiley (Asia) (2000).
2. E. Merzbacher, Quantum Mechanics, John Wiley (Asia) (1999).

References

1. C. Cohen-Tannoudji, Quantum mechanics, John Wiley &sons, 2005
2. P. W. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill (1995).
3. J.J Sakurai, Modern quantum mechanics, Pearson education, 2005
4. L. I. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
5. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, Longman (1993)

PH507: Electrodynamics – I[3 1 0 8]

Electrostatics: Coulomb’s law, electric field, divergence and curl, applications Gauss’s law, electric potential, work and energy, conductor, Laplace equation (1D, 2D and 3D), uniqueness theorem, separation of variables: Cartesian and spherical coordinates, multipole expansion. Dielectrics: Polarization, bound charges, susceptibility, energy and force, boundary conditions, boundary value problems. Magnetostatics: Biot-Savart's Law, Ampere's law, vector potential, magnetic field, moments, force, torque and energy of localized current distributions. Boundary conditions, boundary value problems. Electrodynamics: Electromotive force, Electromagnetic induction, Maxwell's equations, Gauge transformations, potential formulation, energy and momentum conservation, Poynting theorem. Electromagnetic Waves: Wave equation, Propagation of electromagnetic waves in non conducting medium, reflection, transmission, Snell's law, Brewster's angle, critical angle, dispersion in non conducting medium.

Texts:

1. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia) (1999).

References:

1. D.J. Griffith, Introduction to Electrodynamics, Prentice Hall of India, 2nd edition(1975)
2. J. R. Reitz and F. J. Millford, Foundation of Electromagnetic Theory, Narosa (1986).
3. W. Greiner, Classical Electrodynamics, Springer (1998)
4. .L. D. Landau and E. M. Lifshitz, Electrodynamics of Continuous Media, Butterworth Heimemann (1995)

PH508: Electrodynamics – II[3 1 0 8]

Electromagntic Waves: Electromagnetic wave equation, solution and propagation of waves in non-conducting media, polarization, electromagnetic energy, reflection and transmission at oblique incidence, waves in conducting media, absorption and dispersion. Wave Guides: Waves between parallel conductors, TE and TM waves, Rectangular and Cylindrical wave guides. Radiations: Moving Charges, Lienard-Wiechert potential, accelerated charges, angular distribution of radiations, distribution of frequency and energy, Thomson's scattering, Bremsstrahlung in Coulomb collisions. Radiating Systems and Multipole fields: Electric dipole fields and radiations, quadrupole fields, multipole expansion, Energy, angular momentum, multipole radiations. Scattering and Diffraction: Scattering at long wavelengths, perturbation theory, Rayleigh scattering, diffraction theory-Kirchhoff's integral and applications. Special Theory of Relativity: Lorentz Transformations and it's consequences, conservation laws, mass energy relation, relativistic momentum and energy, relativistic force. Relativistic Electrodynamics: Covariant formalism of Maxwell's equations, Transformation laws and their physical significance, relativistic generalization of Larmor's formula, Relativistic formulation of radiation by single moving charge.

Texts:

1. J. D. Jackson, Classical Electrodynamics, John Wiley (Asia) (1999).
2. R. Resnick, Introduction to Special theory of Relativity John Wiley (Asia) (1999)

References:

1. D.J. Griffith, Introduction to Electrodynamics, Prentice Hall of India, 2nd edition(1975)
2. J. R. Reitz and F. J. Millford, Foundation of Electromagnetic Theory, Narosa (1986).
3. W. Greiner, Classical Electrodynamics, Springer (1998)
4. L. D. Landau and E. M. Lifshitz, Electrodynamics of Continuous Media, Butterworth Heimemann (1995

PH509: Computer Programming[2 0 2 6]

Operating systems (DOS/Windows and Linux), graphics packages.

C Programming Language: Algorithms, flow charts, constants, variables, expressions, conditional statements, loops, arrays, logical expressions, control statements, functions, structures, pointers, bit operation, files in C. Solving simple problems using C programming Language.

Texts:

1. V. Rajaraman, Computer programming in C, Prentice-Hall (2000).

References:

1. P. Norton, Complete Guide to Windows, Prentice Hall (1995).
2. K.Srirengan, Understanding Unix, Prentice Hall (1999).
3. B. W. Kernighan and D. M. Ritchie, The C Programming Language, Prentice-Hall (2001).

PH510: Numerical.Methods qnd Computatlonal-Physics[2 0 2 6]

Errors: Sources of error, theory of errors and distribution laws; least square method, curve fitting, statistical assessment of goodness of fit. Roots of Nonlinear Equations: Bisection, Newton-Raphson, secant method. System of Nonlinear equations, Newton's method for Nonlinear systems. Applications in Physics problems. Solution of linear systems: Gauss, Gauss-Jordan elimination, matrix inversion and LU decomposition. Eigenvalues and Eigenvectors. Applications. Interpolation and Curve fitting: Introduction to interpolation, Lagrange approximation, Newton and Chebyshev polynomials. Least square fitting, linear and nonlinear. Application in Physics problems. Numerical Differentiation: Approximating the derivative, numerical differentiation formulas, Numerical Integration: Quadrature Formula, trapezoidal and Simpson's rule, Gauss-Legendre integration. Applications. Solution of ODE: Initial value and boundary value problems, Euler's and Runge-,Kutta methods, Finite difference method. Applications in Chaotic dynamics, Schrodinger equations. Solution of PDE: Hyperbolic, Parabolic, and Elliptic Equations by finite difference. Application to 2-dimensional Electrostatic Field problems.

Texts:

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill (2002).

References:

1. J. H. Mathews, Numerical Methods for Mathematics, Science, and Engineering, Prentice Hall of India (1998).
2. S. S. M. Wong, Computational Methods in Physics, World Scientific (1992).
3. W. H. Press, S. A. Teukolsky, W. T. Verlling and B. P. Flannery, Numerical Recipes in C, Camb ridge (1998).

PH511: Physics Laboratory-I[0 0 6 6]

1. Dielectric Constant and Curie temperature of a semiconductor.
2. Hall Effect in semiconductors.
3. Electrical resistivity of semiconductors.
4. Young's modulus.
5. Magnetic susceptibility of a liquid.
6. Study of magnetic hysteresis.
7. Polarization of light.
8. Newton's Ring

References:

1. R. A. Dunlop, Experimental Physics, Oxford University Press (1988).
2. A. C. Melissinos, Experiments in Modern Physics, Academic Press (1996).

PH512: Physics Laboratory-II[0 0 6 6]

1. I-V characteristics of a Zener and voltage regulation.
2. half-wave, full-wave and bridge rectifier circuits.
3. I/O characteristics of BJT in CB and CE configuration.
4. Single stage amplifier using a FET; OP-Amp. Circuits.
5. Inverting and non-inverting amplifier, addition, subtraction, differentiation and integration.
6. ColI pitt and Wien bridge oscillators.
7. Monostable and Astable multivibrator using NE555.
8. Truth table of logic gates.
9. Universality of NOR/NAND gates.
10. Verification of De Morgan's theorem

References:

1. P. B. Zbar and A. P. Malvino, Basic Electronics: a text-lab manual, Tata McGraw Hill (1983).
2. D. P. Leach, Experiments in Digital Principles, McGraw Hill (1986).
3. R. S. Gaonkar, Microprocessor Architecture: Programming and Applications with the 8085, Penram India (1999).

PH601: Atomic and Molecular Physics[3 1 0 8]

Review of atomic structure of H, two electron systems. Many electron atoms: Central field approximation, Thomas-Fermi model, Hartee-Fock method and self-consistent field, Hund's rule, L-S and j-j cuopling. Interaction with Electromagnetic fields: Selection rules, spectra of alkalis, Helium and alkaline earths, multiplet structure, Zeeman and Stark effect. Molecular structure: General nature, Born-Oppenheimer separation, rotation and vibration of diatomic molecules, electronic structure of diatomic molecules, structure of polyatomic molecules. Molecular spectra: Rotational, vibrational, electronic spectra of diatomic molecules, electronic spin and Hund's cases and nuclear spin, Raman and Infra-Red spectrums. Atomic collisions: Types of collisions, channels, thresholds, cross-sections, potential scat- tering, general features, Born approximation. Resonance Spectroscopy: NMR, NQR, ESR and Mossbauer spectroscopies.

Texts:

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules, Longman (1996).
2. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Wiley India Pvt. Ltd, (2006)

References:

1. C. N Banwell and E.M McCash, Fundamentals of Molecular Spectroscopy, Tata McGraw Hill (2007)
2. H. E. White, Introduction to Atomic Spectra, Tata McGraw Hill (1934).

PH602: Instrumentation[2 0 3 7]

Sensors: Resistive, capacitative, inductive, electromagnetic, thermoelectric, elastic, piezoelectric, piezoresistive, photosensitive and electrochemical sensors; interfacing sensors and data acquisition using serial and parallel ports. Low pressure: Rotary, sorption, oil diffusion, turbo molecular, getter and cryo pumps; Mcleod, thermoelectric (thermocouple, thermister and pirani), penning, hot cathode and Bayard Alpert gauges; partial pressure measurement; leak detection; gas flow through pipes and apertures; effective pump speed; vacuum components. Low temperature: Gas liquifiers; Cryo-fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement. Analytical Instruments: X-ray diffractometer; Spectrophotometers; FT-IR; DSC; lock-in amplifier; spectrum analyzer, fluorescence and Raman spectrometer, scanning electron microscope, atomic force microscope, interferometers. Laboratory component: physical parameter measurement using different sensors; low pressure generation and measurement; calibration of secondary gauges; cryostat design; CCR operation; data collection from analytical instruments in the department.

References:

1. A. D. Helfrick and W. D. Cooper, Modern electronic instrumentation and measurement techniques, Prentice Hall of India (1996).
2. J. P. Bentley, Principles of measurement systems, Longman (2000).
3. G. K. White, Experimental techniques in low temperature physics, Calrendon (1993).
4. A.Roth, Vacuum technology, Elsevier (1990).
5. D. A. Skoog, F. J. Holler and T. A. Nieman, Principles of Instrumental analysis, Saunders CoIl. Publ. (1998).

PH603: Solid State Physics[3 1 0 8]

Crystal physics: Crystalline and amorphous materials, crystal systems; Bravais lattices; Miller Indices; symmetric elements; symmetric groups; reciprocal lattice; Brillouin zone; point, line, surface and volume defects; colour centers ; crystal bindings; ionic bond, covalent bond,molecular bond, hydrogen bond, metallic bond & Van der waals bond; diffraction: X-ray, electron and neutron. Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; phonons and quantization; Brillouin zones; thermal conductivity of metals and insulators. Electronic properties: Free electron theory of metals; electrons in a periodic potential; Bloch equation; Kronig-Penny model; band theory; metal, semiconductor and insulators; bandgap; intrinsic and extrinsic semiconductors, Hall Effect, p-n junction. Dielectrics: Polarizability; Clausius-Mossotti formula; Dielectric constant; ferroelectrics. Magnetism: Diamagnetism, paramagnetis'm, ferromagnetism, antiferro magnetism and ferrimagnaetism. Superconductivity: Meissner effect; London equations; coherence length; type-I and typeII superconductors.

Texts:

1.H. P. Myers, Introduction to Solid State Physics, Viva books (1998).
2. M.A. Omar, Elementary Solid State Physics, Addison-Wesley (1975).

References:

1. C. Kittel, Introduction to Solid State Physics, John Wiley (1996).

2. A. J. Dekker, Solid State Physics, Macmillan (1986).
3. N. W. Ashcroft and N. D. Mermin, Solid State Physics, HBC Publ., (1976).

PH605: Nuclear and Particle Physics[3 1 0 8]
Nuclear properties and forces: radius, size, mass, spin, moments, abundance of nuclei, binding energy, deuteron, n-n and p-p interaction, nature of nuclear force. Nuclear Models: liquid drop, shell and collective models. Nuclear decay and radioactivity: radioactive decay, detection of nuclear radiation, alpha, beta and gamma decays, radioactive dating. Nuclear reactions: conservation laws, energetics, isospin, reaction cross section, Coulomb scattering, nuclear scattering, scattering cross section, optical model, compound nucleus, direct reactions, resonance reactions, neutron physics, fission, fusion. Particle accelerators and detectors: electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, gas-filled counters, scintillation detectors, semiconductor detectors. Elementary particles: forces, quantum numbers, mesons and Yukawa's hypothesis, pions, CPT theorem, strange mesons and baryons, production and decay of resonances, CP violation in K decay. Particle physics: Symmetries and conservation laws, Feynman diagrams, Gell-MannNishijima relation, Quark model, coloured quarks and gluons, quark dynamics, standard model.

Texts:
1. K. S. Krane, Introductory Nuclear Physics, John Wiley (1988).

Reference:
1. R. R. Roy and B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age (1967).
2. A. Das and T. Ferbel, Introduction to nuclear and particle physics, John Wiley (1994).
3. D.C. Tayal, Nuclear physics, 4^{th} edition, Himalaya House, Bombay(1980)
4. F. Halzen and A. D. Martin, Quarks and Leptons, John Wiley (1984).

PH607: Statistical Mechanics[3 1 0 8]
Review of Thermodynamics: Laws of thermodynamics, entropy, thermodynamic potential and Maxwell’s relation, chemical potential and phase equilibria. Statistical Thermodynamics: Macrostates, microstates and accessible microstates, fundamental postulate of equilibrium of statistical mechanics. Canonical Ensemble: Equilibrium between system and heat reservoir, partition function, energy fluctuation, equipartition and Virial theorem, harmonic oscillators, statistics of paramagnetism, thermodynamics of magnetic system. Grand Canonical Ensemble: Equilibrium, partition function, density and energy fluctuation, correspondence with other ensembles, examples. Formulation of Quantum Statistics: Quantum mechanical ensemble theory, density Matrix, statistics of various ensembles- microcanonical, canonical, grand canonical, examples. Theory of Simple Gasses: Ideal gas in different quantum mechanical ensembles. Systems of: monatomic, diatomic and polyatomic molecules. Ideal Bose Gas: Thermodynamics, Bose-Einstein condensation, blackbody radiation, phonons, elementary excitation in Helium II. Ideal Fermi Gas: Thermodynamics, Pauli paramagnetism, Landau diamagnetism, DeHassVan Alphen Effect, thermionic and photoelectric emissions, white dwarfs. Interacting Systems: Cluster expansion, Virial Expansion, evaluation of Virial coefficients.

Texts:
1. R. K. Pathria, Statistical Mechanics, Butterworth-Heinemann (1996).

References:
1. B.B Laud, Fundamentals of Statistical mechanics, New age publication, 2007
2. F. Reif, Statistical and Thermal Physics, McGraw-Hill (1985).
3. W. Greiner, L Neise, and H. Stocker, Thermodynamics and Statistical Mechanics, Springer (1994).
4. K. Huang, Statistical Mechanics, John Wiley Asia (2000).
5. L. D. Landau and E. M. Lifshitz, Statistical Physic~I, Pergamon (1980).

PH611: Physics Laboratory III[0 0 6 6]
1. Michelson interferometer, wave guides, etc.
2. Monatomic and diatomic lattice characterisation
3. Photo-voltaic effect.
4. Magneto-resistance of semiconductors.
5. X-ray diffraction.
6. Zeeman effect, emission spectra of gases.
7. Study of alpha and Gamma-rays, etc.

References:
1. R. A. Dunlop, Experimental Physics, Oxford University Press (1988).

2. A. C. Melissinos, Experiments in Modern Physics, Academic Press (1996).

PH621: Project I
PH622: Project II

PH5xx: Electives

PH631: Magnetism and Superconductivity[3 1 0 8]

Magnetism: Review of diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferri magnetism. Circular and helical order. Direct, exhange, double exchange, indirect and RKKY interactions. enviroment effects: crystal field, tetrahedral and octahedral sites; Jahn- Teller effect; Hund's rule and rare earth ions in solids. Consequences of broken symmetry, phase transition, Landau's theory, rigidity, excitation, magnons, domains and domain walls, magnetic hysteresis, pinning effects. Magneto resistance, giant magneto resistance, nuclear magnetic resonance, technological aspects of magnetic materials. Superconductivity: Superconductivity basics; physical properties below Tc, duration of persistent currents, London and Pippard equation, Type II superconductors, intermediate state, vortex lines; flux pinning; Non-ideal behaviour of Type II superconductors; Thermodynamics of Type I and II superconductors; Ginzburg Landau (G-L) theory; G-L equations; current density; Josephson equations; superconducting quantum interference device. Cooper pairs and BCS theory; Energy gap; magic number; experimental determination of energy gap from I- V characteristics; Magnetic field effects on superconductors, high Tc Superconductors, cuprate superconductors, wires and tapes , iron and carbon based superconductors,superconducting magnets.

References:

1. S. Blundell, Magnetism in Condensed Matter, Oxford (2001).
2. D. Craik, Magnetism: Principles and Applications, John Wiley (1995).
3. J. B. Ketterson and S. N. Song, Superconductivity, Cambridge (1999).
4. T. P. Sheahen, Introduction to high-temperature Superconductivity, Plenum (1994).
5. M. Tinkham, Introduction to Superconductivity, McGraw Hill (1996).
6. A. C. Rose-Innes and E. H. Rhoderick, Introduction to Superconductivity, Pergamon (1978)
7. B. D. Cullity and C.D. Graham, Introduction to Magnetic Materials, Wiley, NJ,(2009)
8. S. Chikazumi, Physics of Ferromagnetism, Oxford University Press (1997).
9. C. Kittel, Introduction to Solid State Physics, 7th edition, Wiley (2006).
10. F. C. Moon, Superconducting Levitation, Wiley (2004).

PH632: Crystal Physics and Symmetry[3 1 0 8]

Crystal Physics: External symmetry elements of crystals. Concepts of point groups. Influence of symmetry on Physical properties : Electrical conductivity. Space groups, derivation of equivalent point position (with examples from triclinic and monoclinic systems),experimental determination of space group. Examples of structures such as NaCl, CsCl, the diamond structure, cubic perovskite structure. ; Fundamental principle of x-ray diffraction, Scattering of x-ray by electron and atoms, Structure factor and Intensity. Typical crystal structure determinations from x-ray powder diffraction data. Determination of crystallite size and strain from x-ray diffraction pattern. Crystal symmetry and macroscopic physical properties, Symmetry of higher rank tensors and their applications to crystal properties, pyroelectricity, ferroelectricity, electrical conductivity, piezoelectricity, magnetic susceptibility and elasticity tensors.

Reference :

1. M.Ali Omar: Elementary Solid State Physics
2. Handbook of Nanostructured Materials and Nanotechnology (Vol. 1 to 4). Ed. Hari Singh Nalwa
3. N.W.Ashcroft and N.D. Mermin, Solid State Physics, Brooks Cole, 1976
4. Introduction to Solid State Physics by C Kittel.
5. Thin film Technology, By KL Chopra, Mcgraw Hill
6. H.P.J Smit and Wijn, Ferrites, Philips Technical Library, Einthoven, Netherland, 1959
7. Elements of X-Ray diffraction, By BD Cullity

PH633: Thin Film Phenomena[3 1 0 8]

Theory: Basic definitions; thin film deposition methods; PVD, CVD, Liquid phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, metal organic vapour phase epitaxy, sputtering (RF & DC), pulsed laser

deposition.
Characterisation: Structural, optical, electrical and mechanical characterization of films, metallic, semiconducting and insulation films, non-crystalline films. Optoelectronic devices: LED, LASER, Solar cell, Micro Electromechanical Systems (MEMS), Giant Magnetoresistance (GMR), thin film transistor and FET.

References:

1. K.L. Chopra, Thin Film Phenomena, McGraw- Hill book company New York, (1969).
2. Ludminla Eckertova, Physics of Thin Films, Plenum press, New York (1977).
3. A. Goswami, Thin Film Fundamentals, New Age international (P) Ltd. Publishers, New Delhi (1996).

PH634: Physics of Material synthesis and characterisation[3 1 0 8]

Bulk Materials Synthesis Techniques: Powders synthesis method; mechanical methods, hydrothermal synthesis of ceramic oxide powders, chemical methods, synthesis of nano-scale ceramic powders, powder characterization, particle size, shape, surface area, chemical composition, crystal structure and phase composition. Thin Film Synthesis Techniques: Physical vapor deposition, Chemical vapor deposition, Pulsed LASER Deposition, Sol-Gel. Characterization Techniques: X-Ray Diffraction Methods, X-Ray Fluorescence, Electron Dispersion Spectroscopy, Thermo gravimetric Analysis, Differential Thermal Analysis, Differential Scanning Calorimetery, Electron Microscopy-Transmission and Scanning Electron Microscopy, STM and AFM, Compositional analysis employing Electron Probe Microanalysis, Spectroscopy. Nano-materials synthesis, Top down and bottom up approach, Solid Phase (Physical) methods, Liquid Phase (Chemical) methods, Gas phase methods, Some application to Nanotechnology.

References:

1. M. N. Rahaman, *Ceramic Processing*, CRC Press, Taylor & Francis Group, FL, (2007)
2. C. M. Srivastava and C. Srinivasan, Science of Materials Engineering, 2nd Edition, (New Age International), (2005)
3. C. P. Poole and F. J. Owens, Introduction to Nanotechnology, Wiley & Sons, 2006
4. G. Cao ,Nanostructures & Nanomaterials, Synthesis Properties & Applications, , Imperial Press (2006)
5. K.L. Chopra, Thin Film Phenomena, McGraw- Hill book company New York, (1969).

PH 641: Laser Physics[3 1 0 8]

Brief history of LASER, wave nature of light, wave-particle duality, Electromagnetic radiation, interaction of light with matter, Black body radiation, General Physical principles behind amplification: Spontaneous emission. Stimulated absorption, Stimulated emission, Einstein coefficient and amplification, Line broadening, Ideas about line-width, Laser rate equations: The three level system, The four level system, Semi classical theory of LASER, active medium, population inversion, pumping mechanism, Role of feedback mechanism, Optical resonator, Modes of a rectangular cavity, Transverse and Longitudinal modes, The quality factor, Q- switching, Mode locking. CW operation, Pulsed operation. Properties of LASER: Coherence, Directionality and Monochromacity. Different types of LASERS: Gas LASER, Solid state LASER, Liquid state LASER, Excimer LASER, Fiber
Optic LASER

Essential Readings:

1. William T. Silfvast, LASER Fundamentals, Cambridge University Press, 2nd Edition, (2004).
2. Anthony E. Siegman, LASERS, University Science Books, (1986).
3. A.K. Ghatak and K.Thyagarajan, LASERS: Theory and applications, Macmillan Publishers India, (2000).
4. K.R. Nambiar, LASERS: Principles, Types and Applications, New Age Instruments, (2004).
5. Orazio Svelto and David C. Hanna, Priniciples of LASERS, Springer, 4th Ed, (1998)
6. O. Svelto, Principles of Laser, Plenum (1998).
7. W. T. Silfvast, Laser and Fundamentals, Cambridge (1996).
8. A. E. Seigman, Lasers, Oxford (1986).
9. A. Yariv, Quantum Electronics, John Wiley (1988).

PH 642: Laser Spectroscopy[3 1 0 8]

Interaction of radiation with matter, strong field approximation, Rabi oscillations, line widths, Doppler limited spectroscopy, laser induced absorption and fluorescence spectroscopy, optogalvanic spectroscopy, high resolution spectroscopy, double resonance techniques, Laser Raman spectroscopy, time resolved laser spectroscopy, homo dyne and hetrodyne spectroscopy, measurement of ultrashort pulses, pump and probe techniques, quantum beat spectroscopy, photon echo, correlation spectroscopy, single ion spectroscopy, atom interferometry, polarization spectroscopy, Laser cooling, multiphoton transistions.

References:

1. W. Demtroder, Laser Spectroscopy Basic Concepts and Instruments, Springer (1996).
2. M. S. Feld and V. S. Lethokov, Non linear laser Spectroscopy, Springer (1980).
3. S. Stenholm, Foundations of laser spectroscopy, Wiley (1999).
4. V. I. Balykin and V. S. Lethokov, Atom Optics with Laser Light, Harwood Academic Publishers (1995).

PH 643: Fibre Optics[3 1 0 8]

Optical fibre principle, Ray and modal analysis of single and multimode fibers (step index and graded index), material dispersion, losses, coupling polarization, leaky modes, pulse chirping, solitons, fiber optic communication system, WDM, fiber amplifiers, switches. Fiber optics sensors and application, optical components, sources and detectors for fibre, optical integrated devices, experiments based on characterization of optical fibre.

References

1. K. Okamoto, Fundamentals of Optical Waveguides, Academic Press (2000).
2. A. K. Ghatak and K. Thyagarajan, Introduction to Fiber Optics, Cambridge (1999).
3. N. S. Kapany, Fiber Optics: Principles and Applications, Academic Press l1998).
4. G. Keiser, Optical Fibre communication, McGraw **Hill** (1991).

PH651: Quantum Information Theory[3 1 0 8]

Brief review of basic concepts, Density operator representation, Pure and mixed states, Reduction postulate, Theory of measurement, The von Neumann theory, Einstein-Podolsky- Rosen arguments and incompleteness, Hidden variables, Bell's inequalities, Gleason's Theorem, Dense coding, Teleportation, Bell-state analyzer, Entanglement swapping, Quantum networks, Transmission of quantum states, Multiparticle entanglement, GHz states, Entanglement quantification, The von Neumann entropy, Kochen-Specker construction, Lattice propositions.

References:

1. D. Bouwmeester, A. Ekert and A. Zeilinger, The Physics of Quantum Information, Springer (2000).
2. MacChiavello, Palma, and Zeilinger, Quantum Computation and Quantum Information Theory, World Scientific (2000).

PH652: Phase Transitions and Critical Phenomena[3 1 0 8]

Critical Phenomena: Phase transitions in different systems, First order and second order, Thermodynamics and statistical mechanics of phase transition, Critical point exponents and exponent inequalities. Models: Spin-l/2 and Spin-l Ising Models, q-state Potts model, X-Y and Heisenberg models. Universality. Mean Field Theory: Mean Field Theory for Ising model, Landau theory, Correlation functions, Classical mean field theories, Scaling hypothesis. Transfer matrix: Setting up the transfer matrix, Calculation of free energy and correlation functions, Results of Ising model. Series Expansion: High and low temperature series, application in 1-d Ising model, Analysis of series. Monte Carlo: Importance sampling, Metropolis algorithm, Data analysis, statistical error, finite-size effect. Examples Renormalization Group: Definition of a RG transformation, Flow in parameter space, Universality, Scaling and critical exponents, scaled variables. Application in 1-d Ising model.

References:

1. H. E. Stanley, Introduction to Phase transitions and Critical Phenomena, Oxford (1971).
2. J. M. Yeomans, Statistical Mechanics of Phase transitions, Oxford (1992).
3. K. Huang, Statistical Mechanics, John Wiley (2000).
4. R. K. Pathria, Statistical Mechanics, Oxford (1999).
5. M. Plischke and B. Bergersen, Equilibrium Statistical Physics, Prentice Hall (1989).

PH655: General Theory of Relativity[3 1 0 8]

Review of Riemannian geometry: Metric tensor, covariant differentiation, curvature tensor, Bianchi Identities, Ricci tensor. Motion of a particle in a gravitational field, geodesic. Equations of electrodynamics in the presence of a gravitational field. Gravitational field equations: Action for gravitational field, Energy-momentum tensor, Extremum principle, Einstein field equations, Energy-momentum pseudotensor. Field of gravitating bodies: Schwarzschild solution, Birkhoff's theorem, Motion in a centrally symmetric gravitational field, Precession of perihelion of Mercury, Deflection of light, Gravitational lens. Black holes: Schwarzschild black holes, Kruskal space, Black hole thermodynamics. Gravitational waves: Plane waves, Weak field approximation, Gravitational radiation, Transverse-traceless gauge, Electromagnetic analogy. Cosmological constant: Einstein space, de Sitter space, Anti-de Sitter space. Relativistic Cosmology: Thermal background, Hubble expansion, Big bang, Age and density of the universe. Introduction to Friedmann-Robertson-Walker universe.

References:

1. W. Rindler, Relativity---Special, General, and Cosmological, Oxford University Press, New York, 2001.
2. C. W. Misner, K. S. Thorne, and J. A. Wheeler, Gravitation, Freeman, NewYork, 2000.
3. L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields, Butterworth Heinmann,1996
4. J. V. Narlikar, Introduction to Cosmology, Cambridge University Press, New Delhi, 1993.
5. A. Einstein, The Meaning of Relativity, Oxford & IBH, 1990.
6. P. A. M. Dirac, General Theory of Relativity, Prentice Hall of India, 2001.
7. W. Pauli, Theory of Relativity, Dover, 1981.
8. R. P. Feynman, F. B. Moronigo, and W. G. Wagner, Feynman Lectures on Gravitation, Addison-Wesley, 1995
9. S. Wienberg, Gravitation and Cosmology, John Wiley, 2004 (Indian Reprinting).

PhD PHYSICS SYLLABUS

PH701 QUANTUM MECHANICS[3 0 0 6]

One dimensional problems: potential wells, potential steps and potential barriers, Harmonic oscillator, Hydrogen Atom; Spherically symmetric potentials: Bound States and scattering, Partial wave method, the Born approximation; Time-independent and Time-dependent perturbation theory, WKB approximation, Symmetry in Quantum Mechanics, Identical particles and spin. Interaction of Atoms with Electromagnetic Radiation, L-S Coupling, J-J Coupling, line width and transition probability, fine and hyperfine structure, Zeeman's and stark effect, Clebsch-Gordon Coefficients, Pauli Matrices, Scattering Theory, the Quantum Theory of Radiation, Relativistic Quantum Mechanics of Spin ½ particles. Elementary introduction to relativistic quantum mechanics: the Klein Gordon and Dirac equations. Interparticles, Antiparticles.

References:

1. J.J. Sakurai, Advanced Quantum Mechanics, Pearson Education (2002)
2. C. Cohen-Tannoudji, Quantum mechanics, John Wiley &sons, 2005
3. L. I. Schiff, Quantum Mechanics, Mcgraw-Hill (1968).
4. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, Longman (1993)
5. L. D. Landau and E. M. Lifshitz, Quantum Mechanics, Third Edition, Elsevier Butterworth Heinemann (2005).

PH702 CLASSICAL MECHANICS[3 0 0 6]

Review of point-particle mechanics, Lagrangian mechanics of point particles and rigid bodies, Rotating frames of reference, terrestrial applications; Central forces, Conservation of energy and angular momentum, Characteristics of bounded orbits, Kepler problem, planetary orbits, Kepler equation; Conservation of electricity vector, Rutherford scattering formula;

Legendre transformations, Hamiltonian description, Phase portraits of simple systems;

Classical theory of real and complex scalar fields, Noether's theorem, Symmetries and conserved currents, Lagrangian description of classical fluids, Navier Stokes Equation, Energy momentum tensor, Hamiltonian and Lagrangian description of the electromagnetic field, Gauge invariance, Lagrangian description of general relativity.

References

1. Herbert Goldstein , Classical Mechanics (2nd Edition) (2001)
2. L. D. Landau and E.M. Lifshitz, Mechanics, Oxford (1981)
3. N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw Hill, (1991).

PH703 STATISTICAL MECHANICS[3 0 0 6]

Microstates and Macrostates, Ensemble theory, Ergodic hypothesis, Liouville's theorem, Microcanonical, Canonical and Grand Canonical ensembles, Partition function and its applications, Equipartition and Virial theorems. Quantum Statistics, Density matrix and its applications, ideal quantum gas, MB, FD and BE statistics, BE condensation, cold atoms, Fermi gas in metals, white dwarf stars, superconductivity, Transport phenomena, Diffusion, Boltzmann transport equation, interacting systems, Ising model, Ginzburg-Landau equations, Random Walk problem.

Sampling probability distributions, Chi-square, F-, and t-distribution, Random number generation,Monte Carlo techniques, Least Squares Method. Maximum Likelihood. Minimization methods, Generalized least squares method, Chi-Square Method.

References

1. R.K. Pathria, Statistical Mechanics, Butterworth-Heinemann, 2nd Ed. (1996)
2. F. Reif, Fundamentals of Statistical and Thermal Physics, (International Student Ed.) Tata McGraw Hill.
3. K. Huang, Statistical Mechanics, John Wiley & Sons, 2nd Ed.(2000)
4. W. Greiner, L. Neise, and H. Stocker, Thermodynamics and Statistical Mechanics, Springer (1995).

PH704 ELECTRODYNAMICS[3 0 0 6]

Maxwell's equations, Boundary value problems, Solution of Laplace's and Poisson's equations, multipole expansion and Green's function approach, Electromagnetic waves in dielectric and conducting media, Waveguide, Radiation: Retarded potential, Lienard-Wiechert potential, accelerated charges, radiation from an oscillating electric dipole fields and Bremsstrahlung radiation, Scattering: scattering at long wavelengths, Thomson and Rayleigh scattering, Born approximation; Relativistic electrodynamics: covariant formalism of Maxwell's equations.

References

1. J. D. Jackson, Classical Electrodynamics, John Wiley (1999).
2. L. D. Landau and E. M. Lifshitz, Electrodynamics of Continuous Media, Butterworth (1995).
3. G. S. Smith, Classical Electromagnetic Radiation, Cambridge (1997).
4. D. J. Griffiths, Introduction to Electrodynamics, Prentice-Hall (1999).
5. J. R. Reitz and F. J. Millford, Foundation of Electromagnetic Theory, Narosa (1986).

PH705 CONDENSED MATTER PHYSICS [3 0 0 6]

Physical applications of Group theory in crystals: Crystal field splitting and other related problems. Elastic Scattering of waves: Interference of Waves, Elastic scattering by Crystals, Experimental Techniques, Scattering from surfaces, Scattering from amorphous solids.

Magnetic Properties: Diamagnetism and Para magnetism, Ferromagnetism, Ferri and anti ferromagnetism, Spin waves, Magnetic resonance phenomenon. Micro-structural properties its measurements techniques, mechanical properties, electrical, thermal, magnetic etc. surface analysis and depth profiling, techniques for physical property measurement, processing and properties of inorganic nanomaterials, special nanomaterials. Strongly correlated quantum systems - giant magnetoresistance, high-Tc superconductivity, qua ntum phase transitions.

Optical and transport properties of bulk and thin film semiconductors, Photoluminescence, Photoreflectance, magneto-transport in narrow gap semiconductors, Amorphous semiconductor, Spintronics & Magnetism.

References

1. N.W.Ashcroft and N.D. Mermin, Solid State Physics, Brooks Cole, 1976
2. C Kittel, Introduction to Solid State Physics, 7th edition, Wiley(2006).
3. J. Richard Christman, Solid State Physics, John Wiley, (1988)
4. H.P.J Smit and Wijn, Ferrites, Philips Technical Library, Einthoven, Netherland, (1959)
5. BD Cullity, SR Stock , Elements of X-Ray diffraction, 3rd edition (2002)
6. GM Bancroft , Mossbauer Spectroscopy, Wiley, (1973)

PH706 NANOSCIENCE & APPLICATIONS[3 0 0 6]

Nanomaterials and types: nanowires, nanotubes, fullerenes, quantum dots, nanocomposites, top-down and bottom-up approach of synthesis. SEM, TEM, X RD, Atomic Force Microscopy, STM and SPM, Mesoscopic magnetism, miniature Hall detectors, integrated DC SQUID Microsusceptometry, magnetic recording technology, biological magnets.

Basics of nanoelectronics, Single Electron Transistor, quantum computation, tools of micro-nanofabrication, nanolithography, MEMS, NEMS, limits of integrated electronics, drug delivery systems, organic-inorganic nanohybrids, inorganic carriers,nanofluidics.

References

1. BD Cullity, SR Stock , Elements of X-Ray diffraction, 3rd edition (2002)
2. M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Nanotechnology: Basic Sciences and Energy Technologies, Overseas Press (2005).
3. Thin film Technology, By KL Chopra, Mcgraw Hill(1983)