FACULTY OF SCIENCES

SYLLABUS

FOR

M. Sc. (Hons. School) Physics

(Under Credit Based Continuous Evaluation Grading System)

(Semester: I - IV)

Examinations: 2016-17

GURU NANAK DEV UNIVERSITY
AMRITSAR

**(ii) Subject to change in the syllabi at any time.
Please visit the University website time to time.**

M. Sc (Hons. School) Physics

Course Code: PHB 1

Semester I

Course No.	C/E/I	Course Title	Hrs/Week	LTP
PHL-401	C	Analog & Digital Electronics	4	4-0-0
PHL-402	C	Electrodynamics-I	4	4-0-0
PHL-403	C	Condensed Matter Physics-I	4	4-0-0
PHL-405	C	Quantum Mechanics	4	4-0-0
PHP-422	C	Electronics Lab	6	0-0-3
PHP-423	C	Computational Lab	6	0-0-3
			Total Credit	**22**

Semester II

Course No.	C/E/I	Course Title	Hrs/Week	LTP
PHL-452	C	Electrodynamics-II	4	4-0-0
PHL-453	C	Condensed Matter Physics-II	4	4-0-0
PHL-454	C	Nuclear Physics	4	4-0-0
PHL-455	C	Atomic and Molecular Spectroscopy	4	4-0-0
I-1	I		3	3-0-0
PHP-471	C	Condensed Matter Physics Lab	6	0-0-3
PHP-472	C	Nuclear Physics Lab	6	0-0-3
			Total Credit	**25**

M. Sc (Hons. School) Physics

Course Code: PHB 1

Semester III

Course No.	**C/E/I**	**Course Title**	**Hrs/Week**	**LTP**
PHL-507	C	Particle Physcis	4	4-0-0
PHL-508	C	Advanced Theoretical Techniques	4	4-0-0
E-1	E		4	4-0-0
E-2	E		4	4-0-0
I-2	I		3	3-0-0
PHP-521	C	Advanced Practical Lab	6	0-0-3
			Total Credit	**22**

Any two elective from the following:

PHL-581	Experimental Methods
PHL-584	Material Science
PHL-585	Nanotechnology
PHL-587	Radiation Physics
PHL-588	Plasma Physics
PHL-589	Quantum Computation
PHL-591	Computational Methods
PHL-592	Advanced Electronics
PHL-593	Fabrication of Electronic Devices
PHL-594	Advanced Statistical Mechanics
PHL-595	Digital Signal Processing

*__The courses which are opted in semester III will not be repeated in semester IV__

Semester IV

Course No.	C/E/I	Course Title	Hrs/Week	LTP
E-1	E		4	4-0-0
E-2	E		4	4-0-0
E-3	E		4	4-0-0
I-3	I		3	3-0-0
* PHD-571	C	Project	10	0-0-10
			Total Credit	**25**

Elective Courses

Any three elective from the following:

PHL-581	Experimental Methods
PHL-584	Material Science
PHL-585	Nanotechnology
PHL-587	Radiation Physics
PHL-588	Plasma Physics
PHL-589	Quantum Computation
PHL-591	Computational Methods
PHL-592	Advanced Electronics
PHL-593	Fabrication of Electronic Devices
PHL-594	Advanced Statistical Mechanics
PHL-595	Digital Signal Processing

*** Note: Project will be allotted to the students in semester III.**

Semester-I

ANALOG AND DIGITAL ELECTRONICS

Course No.	**LTP**
PHL-401	**4 0 0**

Switching Devices: Construction and Working of UJT & SCR and their applications in wave generation and power control.

Microwave Devices: Gunn diode, Gunn effect, two valley model, principle and operation of Reflex Klystron.

Optoelectronic devices: Solar cells, Photodetectors, LEDs etc.

Ideal operational Amplifier: Open loop op-amp, inverting amplifier, noninverting amplifier, voltage follower, differential amplifier, difference and common mode gain, common mode rejection ratio.

Operational Amplifier as: Summing, scaling and averaging amplifiers, instrumentation amplifier, integrator and differentiator. Comparator; Schmitt trigger, Multivibrators; Monostable & astable, square wave & triangular wave generators.

D/A Converters, Ladder and Weighted resistor type: A/D convertors, counter type, successive approximation and dual slope converters.

Combinational Logic: The transistor as a switch, OR, AND and NOT gates, NOR and NAND gates, Boolean algebra, Demorgan's theorems, Exclusive OR gate, Karnaugh maps, Decoder/Demultiplexer, Data selector/multiplexer, encoder.

Sequential Logic Flip-Flops: The RS Flip-Flop. JK master slave Flip-Flop, T Flip-Flop, D Flip-Flop, Shift registers, synchronous and asynchronous counters, Mod counters.

Reference Books:

1. Semiconductor Devices (Physics and Technology)- S.M. Sze-Wiley, 1995.
2. Solid State Electronics Devices –BG Streetman and S. Banerjee Prentice Hall, 1999.
3. Microwave Devices and Circuits-Samuel Y Liao-PHI, 1991.
4. OP-Amps and Linear integrated circuits-Ramakanth A. Gayakwad-PHI, 1991.
5. Linear Integrated Circuits-D. Roy Choudhary and Salil Jain-New Age International, 2001.
6. Digital Principles and Applications-AP Malvino and DP Leach-Tata McGraw Hill, 1993.

Semester-I
ELECTRODYNAMICS-I

Course No.	**LTP**
PHL-402	**4 0 0**

Electrostatics: Coulomb's law. Gauss's law, Poisson's equation, Laplace equation. Solution of boundary value problem: Greens function, method of images and calculation of Green's function for the image charge problem in the case of a sphere. Laplace equation, uniqueness theorem. Electrostatics of dielectric media, multipole expansion. Boundary value problems in dielectrics; molecular polarisability Electrostatic energy in dielectric media.

Magnetostatics: Biot and Savart's law. The differential equation of Magnetostatics and Ampere's law , vector potential and magnetic field of a localized current distribution. Magnetic moment, force and torque on a magnetic dipole in an external field. Magnetic materials, Magnetization and microscopic equations.

Time Varying Fields: Time varying fields, Maxwell's equations, conservation laws, Faraday's law of induction, Energy in a magnetic field. Maxwell's displacement current, vector and scalar potential, Gauge transformations; Lorentz gauge, Coulomb Gauge. Poynting theorem, conservation laws for a system of charged particles and electromagnetic field, continuity equation.

Electromagnetic Waves: Plane wave like solutions of the Maxwell equations. Polarization, linear and circular polarization. Superposition of waves in one dimension. Group velocity. Illustration of propagation of a pulse in dispersive medium. Reflection and refraction of electromagnetic waves at a plane surface between dielectrics. Polarization by reflection and total internal reflection. Waves in conductive medium, Simple model for conductivity.

Text and Reference Books:

1. Classical Electrodynamics - J.D. Jackson-John Wiley & Sons Pvt. Ltd., New York, 2004.
2. Introduction to Electrodynamics - D.J. Griffiths-Pearson Education Ltd.,
3. Classical Electromagnetic Radiation -J.B. Marion-Academic Press, New Delhi, 1995.

Semester-I
CONDENSED MATTER PHYSICS-I

Course No.	**LTP**
PHL-403	**4 0 0**

Lattice Specific Heat and Elastic Constants: The various theories of lattice specific heat of solids. Einstein model of the Lattice Specific heat. Density of modes of vibration, Debye model of Lattice specific heat, Born cut-off procedure, specific heat of metals, Elastic strain and stress component. Elastic compliance and stiffness constants. Elastic constants of cubic crystals. Elastic waves in cubic crystals.

Dia, Para and Ferromagnetism: Classification of magnetic materials, the origin of permanent magnetic dipoles, diamagnetic susceptibility, classical theory of Para magnetism, Quantum theory of Para magnetism, Quenching of orbital angular momentum, cooling by adiabatic demagnetization. Paramagnetic susceptibility of conduction electrons, Ferromagnetism, the Weiss molecular field, the interaction of the Weiss field, Ferromagnetic domains, Spin Waves, quantization of spin waves, Thermal excitations of magnons.

Antiferro, Ferrimagnetism: The two sub lattice model, exchange interaction, the structure of ferrites, saturation magnetization, Neel's theory of ferrimagnetisms, Curie temperature and susceptibility of ferrimagnets

Superconductivity: Critical field, Meissner effect, Types of superconductors, specific heat, London equation, penetration depth, coherence length flux quantization. BCS Theory, Tunneling phenomena, Josephson effect, Introduction to high temperature superconductors.

Text and Reference Books:

1. An Introduction to Solid State Physics-C. Kittel-Wiley Eastern Ltd., New Delhi, 1979.
2. Solid State Physics-A. J. Dekkar-Mc millian India Ltd., New Delhi, 2004.
3. Principles of Solid State Physics-R. A. Levy-New York Academy, 1968.
4. Elementary Solid State Physics-Omar-Addison Wesly, 1975.
5. Introduction to solid state Physics-Ashcroft and Mermin-New York Holt, 1976.

Semester-I
QUANTUM MECHANICS

Course No.	LTP
PHL-405	4 0 0

Perturbation Theory: First and second order perturbation theory for non-degenerate and degenerate systems. Perturbation of an oscillator and Anharmonic oscillator, the variation method. First order time dependent perturbation theory, constant perturbation, Calculation of transition probability per unit time for harmonic perturbation. The Helium atom problem. Stark effect.

Scattering theory: Born approximation, extend to higher orders. Validity of Born approximation for a square well potential. Optical theorem. Partial wave analysis, unitarity and phase shifts. Determination of phase shift, applications to hard sphere scattering. Low energy scattering in case of bound states. Resonance scattering.

Relativistic Quantum Mechanics: Klein Gordon equation. Dirac Equation, Lorentz covariance of Dirac equation. Positive and negative energy solutions of Dirac equation, positrons. Properties of gamma matrices. Parity operator and its action on states. Magnetic moments and spin orbit energy.

Identical Particles*:* Brief introduction to identical particles in quantum mechanics (based on Feynmann Vol. III) symmetrisation postulates. Application to 2-electron systems. Pauli exclusion principle. Bose Einstein and Fermi Dirac Statistics.

Text and Reference Books:

1. Modern Quantum Mechanics by J. J. Sakurai (Principal text)-Pearson Education Pvt. Ltd., New Delhi, 2002.
2. Quantum Mechanics by L I Schiff-Tokyo Mc Graw Hill, 1968.
3. Feynman lectures in Physics Vol. III-Addison Wesly, 1975.
4. Quantum Mechanics by Powel and Craseman-Narosa Publication, New Delhi, 1961
5. Quantum Mechanics by Merzbacher-John Wiley & Sons, New York, 1970.

Semester-II
ELECTRODYNAMICS – II

Course No.	**LTP**
PHL-452	**4 0 0**

Wave Guides: Field at the surface of and within a conductor. Cylindrical cavities and wave-guides, modes in a rectangular wave guide, energy flow and attenuation in wave guides. Perturbation of boundary conditions, resonant cavities, power loss in cavity and quality factor.

Relativistic Formulation of Electrodynamics: Structure of space-time, four scalars, four vectors and tensors, relativistic mechanics: proper time and proper velocity, relativistic energy and momentum. Relativistic electrodynamics: Magnetism as a relativistic phenomena and field transformations. Field tensor. Recasting Maxwell equations in the language of special relativity, covariance and manifest covariance, Lagrangian formulation for the covariant Maxwell equations.

Radiating Systems: Fields of radiation of localized oscillating sources, electric dipole fields and radiation, magnetic dipole and electric quadrupole fields, central fed antenna, brief introduction to radiation damping and radiation reaction

Fields of Moving Charges: Lienard Wiechert potential, field of a moving charge. Radiated power from an accelerated charge at low velocities, Larmour's power formula and its relativistic generalization; Angular distribution of radiation emitted by an accelerated charge.

Text and Reference Books:

1. Classical Electrodynamics - J.D. Jackson-John Wiley & Sons Pvt. Ltd., New York, 2004.
2. Introduction to Electrodynamics - D.J. Griffiths-Pearson Education Ltd.,
3. Classical Electromagnetic Radiation -J.B. Marion-Academic Press, New Delhi, 1995.

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CONDENSED MATTER PHYSICS-II

Course No.	**LTP**
PHL-453	**4 0 0**

Defects and Diffusion in Solids: Point defects: Impurities, Vacancies- Schottky and Frankel vacancies, Color centers and coloration of crystals, F-centres, Line defects (dislocations), Edge and screw dislocations, Berger Vector, Slip, Planar (stacking) Faults, Grain boundaries, Low angle grain boundaries, Frank Reed Mechanism and Dislocation Multiplication, the Hydration energy of ions, Activation energy for formation of defects in ionic crystals, interpretation of diffusion in alkali halides, Ionic conductivity in pure alkali halides.

Conductivity of Metals and Luminescence: Electrical conductivity of metals, Drift velocity and relaxation time, the Boltzmann transport equation. The Sommerfeld theory of conductivity, Mean free path in metals, qualitative discussion of the features of the resistivity, Mathiesson's rule Luminescence, excitation and emission, Decay mechanisms, Thallium activated alkali halides. Sulphide phosphors. Electro Luminescence.

Plasmas, Polaritons and Optical Properties: Dielectric function of the electrons gas, plasma optics, transverse and longitudinal modes in plasma, Electrostatic screening, polaritons and LST relations, Electron- phonon interaction, polarons, Kramer-Kroning relations. Liquid Crystals: Introduction, types, physical properties and applications.

Dielectrics and Ferro Electrics: Macroscopic field, The local field, Lorentz field. The Claussius-Mossotti relations, different contribution to polarization: dipolar, electronic and ionic Polaris abilities, General properties of ferroelectric materials. The dipole theory of ferroelectricity, objection against dipole theory Thermodynamics of ferroelectric transitions.

Text and Reference Books:

1. An Introduction to solid state Physics-C. Kittel-Wiley Eastern Ltd., New Delhi, 1979.
2. Solid State Physics-A. J. Dekkar-Mc millian India Ltd., New Delhi, 2004.
3. Principles of Solid State Physics-R. A. Levy-New York Academy, 1968.
4. Elementary Solid State Physics-Omar-Addison Wesly, 1975.
5. Introduction to Solid state Physics-Ashcroft and Mermin-New York Holt, 1976.

Semester-II

NUCLEAR PHYSICS

Course No.	**LTP**
PHL-454	**4 0 0**

Nuclear Interactions: Nuclear forces: Two nucleon system, Deutron problem, binding energy, nuclear potential well, pp and pn scattering experiments at low energy, meson theory of nuclear forces, e.g. Bartlett, Heisenberg, Majorans forces and potentials, exchange forces and tensor forces, effective range theory-spin dependence of nuclear forces-Charge independence and charge symmetry of nuclear forces-Isospin formalism Yukawa interaction.

Nuclear Models : Liquid drop model-Bohr-Wheeler theory of fission-Experimental evidence for shell effects-Shell Model-Spin-Orbit coupling-Magic numbers-Applications of Shell model like Angular momenta and parities of nuclear ground states-Quantitative discussion and estimates of transition rates – magnetic moments and Schmidt lines-Collective model-nuclear vibrations spectra and rotational spectra-applications, Nilsson model.

Nuclear Decay : Beta decay-Fermi theory of beta decay-shape of the beta spectrum- Total decay rate, Angular momentum and parity selection rules-Comparative half-lives-Allowed and forbidden transitions-selection rules-parity violation-Two component theory of Neutrino decay-Detection and properties of neutrino-Gamma decay-Multipole transitions in nuclei-Angular momentum and parity selection rules-Internal conversion-Nuclear isomerism.

Nuclear Reactions: Conservation laws, energetics of nuclear reactions, Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes – Compound nucleus – scattering matrix-Reciprocity theorem-Breit Wigner one level formula-Resonance scattering.

Text and Reference Books

1. A. Bohr and B.R.Mottelson : Nuclear Structure, Vol.. 1 (1969) and Vol. 2, Benjamin, Reading, A. 1975
2. Kenneth S. Krane: Introductory Nuclear Physics, Wiley, New York, 1988
3. G.N.Ghoshal: Atomic and Nuclear Physics Vol. 2 , S. Chand and Co.

Semester-II
ATOMIC AND MOLECULAR SPECTROSCOPY

Course No.	**LTP**
PHL-455	**4 0 0**

Spectra of one and two valance electron systems: Magnetic dipole moments; Larmor's theorem; Space quantization of orbital, spin and total angular momenta; Vector model for one and two valance electron atoms; Spin-orbit interaction and fine structure of hydrogen, Lamb shift, Spectroscopic terminology; Spectroscopic notations for L-S and J-J couplings; Spectra of alkali and alkaline earth metals; Interaction energy in L-S and J-J coupling for two electron systems; Selection and Intensity rules for doublets and triplets

Breadth of spectral line and effects of external fields: The Doppler effect; Natural breadth from classical theory; natural breadth and quantum mechanics; External effects like collision damping, asymmetry and pressure shift and stark broadening; The Zeeman Effect for two electron systems; Intensity rules for the zeeman effect; The calculations of Zeeman patterns; Paschen-Back effect; LS coupling and Paschen –Back effect; Lande's factor in LS coupling; Stark effect

Microwave and Infra-Red Spectroscopy: Types of molecules, Rotational spectra of diatomic molecules as a rigid and non-rigid rotator, Intensity of rotational lines, Effect of isotopic substitution, Microwave spectrum of polyatomic molecules, Microwave oven, The vibrating diatomic molecule as a simple harmonic and an harmonic oscillator, Diatomic vibrating rotator, The vibration-rotation spectrum of carbon monoxide, The interaction of rotation and vibrations, Outline of technique and instrumentation, Fourier transform spectroscopy.

Raman and Electronic Spectroscopy: Quantum and classical theories of Raman Effect, Pure rotational Raman spectra for linear and polyatomic molecules, Vibrational Raman spectra, Structure determination from Raman and infra-red spectroscopy, Electronic structure of diatomic molecule, ,Electronic spectra of diatomic molecules, Born Oppenheimer approximation- The Franck Condon principle, Dissociation and pre-dissociation energy, The Fortrat diagram, Example of spectrum of molecular hydrogen.

Text and Reference Books

1. Introduction to Atomic Spectra: H.E. White-Auckland Mc Graw Hill, 1934.
2. Fundamentals of molecular spectroscopy: C.B. Banwell-Tata Mc Graw Hill, 1986.
3. Spectroscopy Vol. I, II & III: Walker & Straughen
4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo Mc Graw Hill, 1962.
5. Spectra of diatomic molecules: Herzberg-New York, 1944.
6. Molecular spectroscopy: Jeanne L McHale.

Semester-III

PARTICLE PHYSICS

Course No. **LTP**
PHL-507 **4 0 0**

Elementary Particles and Their Properties: Historical survey of elementary particles and their classification, determination of mass, life time, decay mode, spin and parity of muons, pions, kaons and hyperons. Experimental evidence for two types of neutrinos, production and detection of some important resonances and antiparticles.

Symmetries and Conservation laws: Conserved quantities and symmetries, the electric charge, baryon number, leptons and muon number, particles and antiparticles, hypercharge (strangeness), the nucleon isospin, isospin invariance, isospin of particles, parity operation, charge conservation, time reversal invariance, CP violation and CPT theorem, the K^O - K^O doublet unitary symmetry SU(2), SU (3) and the quark model.

Week Interaction: Classification of weak interactions. Fermi theory of beta decay, matrix element, classical experimental tests of Fermi theory. Parity non conservation in beta decay, lepton polarization in beta decay, the V-A interaction, parity violation in P-decay. Weak decays of strange-particles and Cabibbo's theory.

Gauge theory and GUT : Gauge symmetry, field equations for scalar (spin 0), spin (spin ½), vector (spin-1) and fields, global gauge invariance, local gauge invariance, Feynmann rules, introduction of neutral currents. Spontaneously broken symmetries in the field theory, standard model.

Text and Reference Books:

1 Subatomic Physics by H. Fraunfelder and E.M. Henley.

2 Introduction to Elementary Particles by D. Griffiths

3 Introduction to High Energy Physics by D.H Perkins.

Semester-III

ADVANCED THEORETICAL TECHNIQUES

Course No.	LTP
PHL-508	**4 0 0**

Green's functions in 1D: Ordinary differential equations review, influence function, Linear differential operators, Green's identity, adjoint and self-adjoint operators, Sturm-Liouville eigenvalue ODE problems, Fredholm Alternative, Green's functions as eigenfunction expan-sions, dirac delta function and generalized functions, direct approach for determin-ing Green's functions via method of variation of parameters, the wave equation,adjoint Green's function, non Sturm-Liouville problems, modified Green's function and inhomogeneous boundary conditions.

Green's functions in 2 and 3D: Sturm-Liouville problems in 2 and 3D, Green's identity, Multidimensional eigen-value problems associated with the Laplacian operator and eigen function expansions, basics of Bessel functions, Green's function for Laplace's equation in 2 and 3D (unbounded and simple bounded domains) and associated applications, Green's function for Helmholtz equation in 2D (unbounded and simple bounded domains) and associated wave scattering and cloaking problems.

Integral equations in 1D: Linear integral operators and integral equations in 1D, Volterra integral equations govern initial value problems, Fredholm integral equations govern boundary value problems, separable (degenerate) kernels, Neumann series solutions and iterated kernels, applications to scattering.

Integral equations in 2 and 3D: Integral equations associated with Laplace's/Poisson's equation and applications in potential flow, electromagnetism and thermal problems. Eshelby's conjecture for heat conduction. Applications to homogenization and effective material properties. Formulation of integral equation for scalar wave scattering in 2D.

Text and Reference Books:

1. Mathematical methods for Physicists by George B. Arfken, H.J. Weber and F.E. Harris
2. Applied mathematics for Engineers and Physicists by Louis A. Pipes

Elective Paper
(Semester: III & IV)
EXPERIMENTAL METHODS

Course No.	**LTP**
PHL-581	**4 0 0**

Interaction & Detectors*:* Interaction of heavy charged particles, Interaction of fast electrons interaction of gamma rays, Interaction of Neutrons, Radiation exposure & Dose, Angular distribution, Gamma-Gamma angular distribution, Theory of internal Conversion, charged particles, neutrons etc, GM counter, Scintillation detectors, Solid State detectors.

Counting Statistics & Error Prediction: Error analysis, least square fitting, Chi square test, Normal and Poisson distribution, Statistical errors in nuclear particle counting, propagation of errors, Plotting of graphs.

Vacuum & Low Temperature Techniques*:* Vacuum techniques, Basic idea of conductance, pumping speed, Pumps: Mechanical pumps, Diffusion pumps, Ionization pumps, turbo molecular pumps, gauges; Penning, Pirani, Hot cathode, Low temperature: Cooling a sample over a range upto 4 K and measurement of temperature.

Transducers and Temperature Measurements: Classification of transducers, Selecting a transducers, qualitative treatment of strain gauge, capacitive transducers, inductive transducers, linear variable differential transformer (LVDT), photoelectric transducers, piezoelectric transducers, temperature measurements (Resistance thermometer, thermocouples, Themisters).

Text and Reference Books:

1. Electronic Devices and Circuits: Jacob Milliman, C. Halkias
2. Vacuum Technology: A. Roth.
3. Techniques for Nuclear and Particle Physics Experiments: W.R. Leo.
4. Radiation Detection and Measurements: Glenn F. Knell.
5. Electronic Instrumentation and Measurements Techniques: William David Cooper.

Elective Paper
(Semester: III & IV)
MATERIAL SCIENCE

Course No. **LTP**
PHL-584 **4 0 0**

Thin Film Technology*:* Classification of Thin films configurations; Film deposition method: Physical vapor deposition, Chemical vapor deposition, Spray pyrolysis, Sputtering (RF, DC); Modes of film growth by vapor deposition: from vapor to adatoms, from adatoms to film growth, growth modes based on surface energies; film microstructure: Epitaxial films, polycrystalline films, Origin of films stress: classification, stress in epitaxial films, stress in polycrystalline films, consequence of stress in film; effect of substrate temperature, deposition angle and thickness on thin film formation.

Polymers & Ceramics: Characteristics, Application and Processing of polymers; Polymerization, Polymer types: Stress- Strain behaviour, melting and glass transition, thermosets and thermoplasts; Characteristics, Application and Processing of Ceramics, glasses and refrectories.

Characterization Techniques-I: Electrical, Optical and Mechanical method for determination of thickness of films, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM); Scanning tunneling microscopy (STM); Atomic force microscopy (AFM).

Characterization Techniques-II: X-ray diffraction, data manipulation of diffracted X-rays for structure determination; X-ray fluorescence spectrometry for element detection with concentration; Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS), Secondary ion mass spectroscopy (SIMS)

Text and Reference Books:

1. Thin Film Materials-Stress, defect, formation and surface evolution: L.B. Freund and S. Suresh- Cambridge,
2. Thin Film Phenomena :K.L. Chopra-Mc Graw Hill Book, Comp.,1979.
3. Thin Film fundamentals: A. Goswami-New age International, 2007
4. Material Science and Engg :W.D. Callister-John Wiley, 2001
5. Elements of X-ray Diffraction (3rd edition) : B.D. Cullity, S.R. Stock-Prentice Hall, 2001.
6. X-ray Fluorescence spectroscopy: R. Jenkins-Wiley Interscience, New York, 1999.
7. Methods of Surface Analysis : J.M. Walls- Cambridge University Press, 1989.
8. The principles and Practice of Electron Microscopy: Ian M. Watt-Cambridge University Press, 1997
9. Modern techniques for surface science: D.P. Woodruff and T.A. Delchar- Cambridge University Press, 1994.

Elective Paper
(Semester: III & IV)
NANOTECHNOLOGY

Course No.	**LTP**
PHL-585	**4 0 0**

Introduction and Synthesis of Nanomaterials: Basic idea of Nanomaterials and Nanotechnology, Physical Methods: inert gas condensation, arc discharge, Laser ablation, molecular beam epitaxy, electron deposition, ball milling; electron beam lithography; Chemical Methods: sol-gel, micelles and micro emulsions.

Nanoparticles: Introduction to Nanoparticles; Metal Nanoclusters: magic numbers, theoretical modeling of nanoparticles, geometric structure, electronic structure, reactivity, magnetic clusters, bulk to nanotransition; Semiconducting nanoparticles: optical properties, photofragmentation, columbic explosion; Rare gas and molecular clusters.

Quantum Nanostructures: Introduction to quantum wells wires and dots**;** preparation using lithography; Size and dimensionality effects: size effects, conduction electrons and dimensionality, potential wells, partial confinement, properties dependent on density of states, single electron tunneling; Application: Infrared detectors, Quantum dot Lasers.

Carbon Nanostructure: Carbon molecules: nature of carbon bond; new carbon structures; Carbon clusters: small carbon clusters, structure of C_{60}, alkali doped C_{60}; Carbon nanotubes: fabrication, structure, electrical properties, vibrational properties, mechanical properties, Application of carbon nanotubes: field emission and shielding, computers, fuel cells, chemical sensors, catalysis.

Text and Reference Books:

1. Thin Film fundamentals: A. Goswami-New age International, 2007
2. Introduction to Nanotechnology: Charles P. Poole Jr. and Franks J. Qwens,-John Wiley & Sons, 2003.
3. Solid State Physics: J.P. Srivastva-Prentice Hall, 2007.
4. Nanotubes and Nanowires: CNR Rao and A Govindaraj-Royal Society of Chemistry, 2005.

Elective Paper
(Semester: III & IV)
RADIATION PHYSICS

Course No.	**LTP**
PHL-587	**4 0 0**

Ionizing Radiations and Radiation Quantities: Types and sources of ionizing radiation, fluence, energy fluence, kerma, exposure rate and its measurement – The free air chamber and air wall chamber. Absorbed dose and its measurement; Bragg Gray Principle, Radiation dose units- rem, rad, Gray and Sievert dose commitment, dose equivalent and quality factor.

Dosimeters: Pocket dosimeter, films, solid state dosimeters such as TLD, SSNTD, chemical detectors and neutron detectors, simple numerical problems on dose estimation.

Radiation Effects and Protection: Biological effects of radiation at molecular level, acute and delayed effects, stochastic and non-stochastic effects, Relative Biological Effectiveness (RBE), Linear energy transformation (LET), Dose response characteristics. Permissible dose to occupational and non-occupational workers, maximum permissible concentration in air and water, safe handling of radioactive materials. The ALARA, ALI and MIRD concepts, single target, multitarget and multihit theories, Rad waste and its disposal, simple numerical problems.

Radiation Shielding: Thermal and biological shields, shielding requirement for medical, industrial and accelerator facilities, shielding materials, radiation attenuation calculations – The point kernal technique, radiation attenuation from a uniform plane source. The exponential point-Kernal. Radiation attenuation from a line and plane source. Practical applications and some simple numerical problems.

References Books:

1. Nuclear Reactor Engineering -S.Glasstone and A. Seasonke-Van Nostrand Reinhold, 1981.
2. Radiation Theory-Alison. P. Casart
3. Radiation Biology-A.Edward Profio-Prentice Hall, 1968
4. Introduction to Radiological Physics and Radiation Dosimetry -F.H. Attix-Wiley VCH, 1986.

Elective Paper
(Semester: III & IV)
PLASMA PHYSICS

Course No.	LTP
PHL-588	**4 0 0**

Basics of Plasmas: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding and plasma parameter. Single particle motions in uniform E and B, nonuniform magnetic field, grad B and curvature drifts, invariance of magnetic moment and magnetic mirror. Simple applications of plasmas.

Plasma Waves: Plasma oscillations, electron plasma waves, ion waves, electrostatic electron and ion oscillations perpendicular to magnetic field, upper hybrid waves, lower hybrid waves, ion cyclotron waves. Light waves in plasma.

Boltzmann and Vlasov equations: The Fokker Planck equation, integral expression for collision term, zeroth and first order moments, the single equation relaxation model for collision term. Applications of kinetic theory to electron plasma waves, the physics of Landau damping.

Non-linear Plasma Theories: Non-linear effects, Ponderomotive force, KdV Equations, Non-linear Schrodinger Equation, Solitons, Shocks, Non-linear Landau Damping, Sagdeev method.

Reference Books:

1. Introduction to Plasma Physics and Controlled Fusion: F F Chen-Springer, 1984
2. Plasma Physics: R.O. Dendy-Cambridge University Press, 1995.
3. Ideal Magnetohydrodynamics: J P Friedberg-Springer, Edition, 1987.
4. Fundamental of Plasma Physics: S R Seshadri-American Elsevier Pub. Co. 1973.

Elective Paper
(Semester: III & IV)
QUANTUM COMPUTATION

Course No.	**LTP**
PHL-589	**4 0 0**

Introduction to Quantum Information, Review of quantum mechanics, Review of linear algebra and quantum mechanics, Stern-Gerlach experiment, Quantum teleporation

Introduction to computer science, Quantum logic gates- one qubit gate and two qubit gate, Quantum circuits, Quantum algorithms, Private and public key cryptography

Quantum fourier transform, Factoring: Shor's algorithm, Quantum parallelism, Deutch's algorithm, Quantum search algorithm (Grover's search), Quantum error correction

Types of quantum computational schemes: Ions, Neutral atoms, NMR, Quantum dots, Introduction to fault-tolerant quantum computing

References:

1. Quantum Computation and Quantum Information by Michael Nielsen and Isaac L. Chang, Cambridge University Press.
2. Quantum computing by Mika Hervensalo
3. Problems & Solutions in Quantum Computing & Quantum Information by Willi-Hans Steeb and Yorick Hardy.

Elective Paper
(Semester: III & IV)
COMPUTATIONAL METHODS

Course No.	**LTP**
PHL-591	**4 0 0**

Numerical Methods – I : Finite Differences and Interpolation: Difference Operators, Finite differences and differentiation, Interpolation using forward differences, Lagrange's Polynomial Interpolation. Differential Equations: Solving Differential equations by Taylor series method, Euler's method, Runge-Kutta second order and fourth order methods. Differentiation based on equal – interval interpolation, Newton's Backward difference formula, Differentiation based on Lagrange's interpolation formula. Numerical Integration: General Quadrature formula, Trapezoidal, Simpson's one third and three eighth rules, Gauss quadrature formula.

Numerical Methods – II : Solutions of non-linear equations: Bisection method, Newton-Raphson method, System of Linear Equations: Gauss elimination methods, Triangularization method, Inverse of a matrix by compact schemes, Jacobi's iterative method . Eigen values and Eigen vectors : Introduction, properties of eigen values and eigenvectors, Determination of Eigen values and Eigenvectors by Iterative (Power method) and Jacobi methods. Curve Fitting: Fitting Linear equations, Fitting Transcendental equations, Fitting a Polynomial equations.

Matlab – I : Introduction: Basics of MATLAB, working with arrays, creating and printing plots, Interacting Computations: Matrices and Vectors, Matrices and Array Operations, built in functions, saving and loading data, plotting simple graphs Programming in MATLAB: Script files, function files, Compiled files, p-code, variables, loops, branches, and control flow, Input/Output, Advanced data objects, structures, cells.

Matlab – II : Linear Algebra; solving a linear system, Gaussian elimination, finding eigen values and eigen vectors, matrix factorization, Curve fitting and Interpolation; polynomial curve fitting, least square curve fitting, interpolation, Data analysis and statistics, Numerical integration; double integration, Ordinary differential equation; first order linear ODE, second order nonlinear ODE, tolerance, ODE suite, event location, Non linear algebraic equations

Recommended Books:

1. Numerical Methods – S.Balachandra Rao and C.K.Shantha- Stosius Inc/Advent Books Division-2000
2. Numerical Methods – E Balagurusamy-Tata McGraw Hill Publishing Co Ltd-1999
3. Getting Started with MATLAB - Rudra Pratap-Oxford University Press-2005
4. A concise introduction to MATLAB-William J Palm III-McGraw Hill-2008

Elective Paper

(Semester: III & IV)
Advanced Electronics

Course No.	**LTP**
PHL-592	**4 0 0**

Sensors and Transducers.
Temperature, Pressure, Length, Force Optical etc.

Introduction to the general structure of 8 and 16 bit microprocessor and microcontrollers **.** Instruction sets, memory hierarchies of 8 and 16 bit micro controllers.

Interfacing of external memory, I/O devices and serial communication with typical microcontrollers.

Text and Reference Books:

1. The 8051 microcontroller, Architecture programming & applications, 2nd Edition Kenneth J. Ayala, Cengage learning, 2010.
2. The P/C Microcontroller and Embedded systems- Using Assembly and C for PICI8 Muhammad Ali Mazidi,Rolin D. Mc Kinlay and Danny Cansey, Prentice Hall, 2007.
3. M.D. Singh & J. G. Joshi, Mechatronics, 2006, Prentice-hall of India, New Delhi.
4. HMT, Mechatronics Tata Mc Graw Hill, New Delhi.

Elective Paper
(Semester: III & IV)
FABRICATION OF ELECTRONIC DEVICES

Course No.	**LTP**
PHL-593	**4 0 0**

Crystal Growth: Czochralski and Bridgman techniques, Float Zone growth, Distribution coefficients, Zone refining, Wafer preparation and specifications. Epitaxy: importance of lattice matching in epitaxy, CVD of Si, Thermodynamics of vapour phase growth, defects in epitaxial growth, MBE technology.

Diffusion: Fick's diffusion equation in one dimension, Atomistic models of diffusion, analytic solution of Fick' s law for different cases. Diffusivities of common dopants in Si and SiO_2. Diffusion enhancements and retardation, Thermal Oxidation: Deal-Grove model of oxidation. Effects of dopants during oxidation, oxidation induced defects, Ion Implantation: channeling and projected range of ions, implantation damage, Rapid Thermal Annealing (RTA).

Metallization Applications: Gates and interconnections, Metallization choices, metals, alloys and silicides, deposition techniques, metallization problems, step coverage, electromigration, Etching: Dry and wet chemical etching, Reactive Plasma Etching, Ion enhanced etching and ion induced etching.

Optical Lithography: photoresists, Contact and proximity printers, projection printers, Mask alignment, X-ray and electron beam lithography, Fundamental considerations for IC processing: Building individual layers, Junction and Trench isolation of devices.

Recommended Books:

1. The Science and Engineering of Microelectronics Fabrication - SA Campbell - Oxford University Press –1996
2. VLSI Technology - SM Sze - - McGraw Hill International Editions – 1988
3. Fundamentals of Microelectronics Processing - HH Lee - Mc Graw Hill – 1990
4. The Theory and Practice of Microelectronics - SK Gandhi - John Wiley & Sons 1968
5. Silicon VLSI Technology: Fundamentals, Practice and Modeling- James D. Plummer, Michael D. Deal, Peter B. Griffin- Prentice Hall- 2000

Elective Paper
(Semester: III & IV)
ADVANCED STATISTICAL MECHANICS

Course No.	**LTP**
PHL-594	**4 0 0**

Interacting Systems: Deviation of a real gas, Cluster expansion for a classical gas, Virial expansion of equation of state, Evaluation of virial coefficients, General remarks on cluster expansion; quantum mechanical ensemble theory, the density matrix, density matrix for a linear harmonic oscillator; cluster expansion for a quantum mechanics system. Bose condensation.

Phase Transitions and Critical Phenomena: Phase transitions- General remarks on the problems of condensation, Dynamical model for phase transition- Ising and Heisenberg models, the lattice gas and binary alloy, Ising model in the Zeroth approximation, Matrix method for onedimensional Ising model. The critical indices, Law of Corresponding States, Thermodynamic inequalities, Landau's phenomenological theory; Scaling hypothesis.

Brownian Motion: Spatial correlation in a fluid, Einstein- Smoluchowski theory, Langevin theory, The Fokker-Planck equation.

The Time Corelation Function Formalism: Concept of time correlation function, derivation of basic formulas of linear response theory, Time-Correlation function expression for thermal transport coefficients and their applications. The Wiener- Khintchine theorem, the fluctuation dissipation theorem. The Onsagar relations.

TUTORIALS : Relevant problem given at the end of each chapter in R. K. Pathria.

Books:

1. Statistical Mechanics: R. K. Pathria (Butterworth-Heinemann, Oxford), 3rd ed, 2011.

Elective Paper
(Semester: III & IV)
Digital Signal Processing

Course No.	**LTP**
PHL-595	**4 0 0**

Signals and systems: Introduction, classification of signals, representation of signals, elementary discrete-time signals, manipulation of signals, classification of systems, static and dynamic systems, linear systems, time invariant systems, causal and non-causal system, stable and unstable systems, Fourier analysis; trigonometric, complex and exponent forms of Fourier series, Parseval identity, power spectrum, Fourier transform and its properties, Fourier transform of power and energy signals, Z-Transform: Introduction, definition, properties, evaluation of inverse z-transform.

DFT and FFT: The DFT, Properties of DFT: Linearity, periodicity, circular shift of a sequence, time reversal of a sequence, circular frequency shift, complex conjugate property, circular convolution, Hilbert transform, FFT: radix-2 FFT, decimation in time (DIT) algorithm, decimation in frequency (DIF) algorithm. Fast convolution: Overlap-add method, Overlap-save

Finite Impulse Response (FIR) Filters: Introduction, magnitude and phase response of digital filters, frequency response of linear phase FIR filters, design techniques, design of optimal linear

Infinite Impulse Response (IIR) Filters: Introduction, IIR filters design by derivatives, impulse invariant and bilinear transformation method, frequency transformations. Adaptive filters: Theory, structure and applications (speech analysis and mobile communication)

References Books:

1. Digital Signal Processing - Alan V. Oppenhein and Ronald W. Schaffer – Prentice Hall

2. Digital Signal Processing - S Salivahanan, A. Vallavaraj and C Gnanapriya -Tata Mc

3. Digital Signal Processing - S.K. Mitra- Tata McGraw Hill-2005

4. Digital Filter Designers Handbook - C.B. Rorabaugh- Mc Graw Hill-1993

Semester-IV

PROJECT

Course No.	**LT P**
PHD-571	**0 0 10**