FACULTY OF SCIENCES

SYLLABUS

FOR

M. Sc. Physics (CBCEGS)

(Semester: I - IV)

Examinations: 2019-20

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. Physics (Semester System)
(Credit Based Evaluation & Grading System)

SCHEME

Note : All Theory Papers having Mid Semester Marks : 20 & End Semester Marks : 80. Total Marks will be 100.

Semester I

Course No.	C/E/I	Course Title	Hrs/Week	LTP
PHL-401	C	Analog and Digital Electronics	4	4-0-0
PHL-412	C	Mathematical Physics	4	4-0-0
PHL-413	C	Classical Mechanics	4	4-0-0
PHL-414	C	Quantum Mechanics-I	4	4-0-0
PHP-431	C	Computational Lab	6	0-0-3
PHP-432	C	Electronics Lab	6	0-0-3
			Total Credit	**22**

Semester II

Course No.	C/E/I	Course Title	Hrs/Week	LTP
PHL-461	C	Statistical Mechanics	4	4-0-0
PHL-462	C	Electrodynamics-I	4	4-0-0
PHL-463	C	Condensed Matter Physics-I	4	4-0-0
PHL-464	C	Atomic & Molecular Spectroscopy	4	4-0-0
I-1	I		4	4-0-0
PHP-481	C	Condensed Matter Physics Lab	6	0-0-3
PHP-482	C	Spectroscopy Lab	6	0-0-3
			Total Credit	**26**

***Note : PSL-053 ID Course Human Rights & Constitutional Duties (Compulsory Paper). Students can opt. this paper in any semester except the 1st Semester. This ID Paper is one of the total ID Papers of this course.**

M. Sc. Physics (Semester System)
(Credit Based Evaluation & Grading System)

Course Code: PHB 2

Semester III

Course No.	**C/E/I**	**Course Title**	**Hrs/Week**	**LTP**
PHL-451	C	Quantum Mechanics-II	4	4-0-0
PHL-452	C	Electrodynamics-II	4	4-0-0
PHL-456	C	Condensed Matter Physics-II	4	4-0-0
PHL-457	C	Nuclear Physics	4	4-0-0
*PHD-573	C	Project	10	0-0-10
			Total Credit	**26**

Semester IV

Any three elective from the following:

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-2	I		4	4-0-0
PHP-521	C	Nuclear Physics Lab	6	0-0-3
PHP-572	C	Advanced Experiments &Workshop	6	0-0-3
			Total Credit	**22**

Any three elective from the following:

PHL-507	Particle Physics
PHL-508	Advanced Theoretical Techniques
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	Computation Methods
PHL-592	Advanced Electronics
PHL-593	Fabrication of Electronic Devices
PHL-594	Advance Statistical Mechanics
PHL-595	Digital Signal Processing
PHL-596	Reactor Physics
PHL-597	Physics of Semiconductors and Devices

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

M. Sc. Physics (Semester-I)
(Credit Based Evaluation & Grading System)

ANALOG AND DIGITAL ELECTRONICS

Course No. **LTP**
PHL-401 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Semiconductor Materials: Energy Bands, Intrinsic carrier concentration. Donors and Acceptors, Direct and Indirect band semiconductors; Determination of band gap by optical method, Degenerate and Compensated semiconductors, Tunnel Diode and MOSFET: Structure and Working,Structure and Working of UJT, SCR, DIAC, TRIAC and their applications in wave generation and power control

15 Lectures

SECTION-B

Open loop Op-Amp, Inverting Amplifier, Non-Inverting 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, Mono Stable & Astable, Square wave & Triangular wave Generators

15 Lectures

SECTION-C

Digital-to-Analog Converter, Ladder type, Analog-to-digital Convertor, Successive Approximation converter, Combinational Logic:The transistor as a switch, OR, AND and NOT gates,NOR andNAND gates,Boolean algebra, Demorgan’s theorems, Exclusive OR gate, Adder, Karnaughmaps, Decoder/Demultiplexer, Data selector/multiplexer, Encoder.

15 Lectures

SECTION-B

Sequential Logic: The RS Flip – Flop, D Flip - Flop, JK Flip-Flop, JK Master Slave Flip - Flop, T Flip - Flop, Shift registers, Asynchronous and Synchronous counters, Mod Counters, Memory Devices: Static and Dynamic Random access Memories SRAM and DRAM, CMOS and NMOS, non-volatile-NMOS

15 Lectures

Text and Reference Books:

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

M. Sc. Physics (Semester-I)
(Credit Based Evaluation & Grading System)

MATHEMATICAL PHYSICS

Course No. **LTP**
PHL-412 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80
Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Curvillinear coordinates, Differential vector operators in curvillinear coordinates, spherical and cylindrical systems, General coordinate transformation, Tensors: covariant, contravariant and Mixed , Algebraic operations on tensors, Illustrative applications.

15 Lectures

SECTION-B

Definition of a group, multiplication table , conjugate elements and classes of groups, direct product Isomorphism, homomorphism, permutation group, definition of the three dimensional rotation groups and SU(2)Second order differential equations, Frobenius method, wronskian and a second solution, the Strum Liouville theorem, one dimensional Green's function.

15 Lectures

SECTION-C

Gamma functions. The exponential integral and related functions, Bessel functions of the first and second kind, Legendre polynomials, associated Legendre polynomials and spherical harmonics, Generating functions for Bessel, Legendre and associated Legendre functions, Hermite Functions.

15 Lectures

SECTION-D

The Cauchy –Riemann conditions, Cauchy integral theorem, Cauchy integral formula, Taylor and Laurent series, singularities and residues, Cauchy residue theorem, calculations of real integrals. Fourier decomposition, Fourier series and convolution theorem, Fourier transforms and its applications to wave theory.

15 Lectures

Text and Reference Books:

1. Mathematical Methods for Physicists: George Arfken-New York Academy, 1970.
2. Mathematical Physics : P.K. Chattopadhyay
3. Applied Mathematics for Engineers and Physicists: Pipes and Harvil-Tokyo McGraw Hill, 1970.
4. Advanced Mathematical methods for Engg. & Science students: George S. and Radmose P.M-Cambridge University Press, 1990.

M. Sc. Physics (Semester-I)
(Credit Based Evaluation & Grading System)

CLASSICAL MECHANICS

Course No. **LTP**
PHL-413 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Newton's law of motion, mechanics of a system of particles, constraints, D'Alembert's principle and Lagrange's equations of motion. Velocity; dependent potentials and dissipation function. Some applications of Lagrangian formulation, Hamilton's principle, derivation of Lagrange's equations from the Hamilton's principle. Conservation theorems and symmetry properties.

15 Lectures

SECTION-B

Two body central force problem, reduction to equivalent one body problem, the equation of motion and first integrals, the equivalent one dimensional problem, and classification of orbits. The differential equation for the orbit and integrable power-law potential. The Kepler problem. Scattering in a central force.

15 Lectures

SECTION-C

The independent co-ordinates of a rigid body, orthogonal transformation, the Euler's angles. Euler's theorem on the motion of rigid body, finite and infinitesimal rotations, rate of change of a vector, angular momentum and kinetic energy about a point for a rigid body, the inertia tensor and moment of inertia, the eigen values of the inertia tensor and the principal axis transformation. Euler's equations of motion, torque free motion of a rigid body.

15 Lectures

SECTION-D

Legendre transformation and Hamilton's equations of motion, cyclic co-ordinates and conservation theorems, derivation of Hamilton's equations from a variational principle, the principle of least action. The equation of canonical transformation, examples of canonical transformations. Poission brackets. Equations of motion, infinitesimal canonical transformations and conservation theorems in the Poission bracket formulation.

15 Lectures

M. Sc. Physics (Semester-I)
(Credit Based Evaluation & Grading System)

Text and Reference Books:

1. Classical Mechanics: Herbert Goldstein-Narosa Pub. House, 1970.
2. Mechanics: Landau & Lifshitz-Pergamon Press-Oxford, 1982.
3. Classical Mechanics : Rana and Joag-Tata McGraw Hill, New Delhi, 1995.

M. Sc. Physics (Semester-I)
(Credit Based Evaluation & Grading System)

QUANTUM MECHANICS-I

Course No. **LTP**
PHL-414 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Basic Formulation: *One Dimensional Systems:* Potential Step, potential barrier, potential well, Scattering vs. Bounds states. Simple harmonic oscillator, Stern-Gerlach experiment as a tool to introduce quantum ideas, analogy of two level quantum system with polarization states of light.

15 Lectures

SECTION-B

Quantum Kinematics: Linear vector space, ket vector, bra vector, linear operators, Hermitian conjugate, definition of representation, matrix representation of kets, bras and operators, change of representation, eigen values and eigen vectors of an operator, observables and commuting oservables, |r> and |p> representations.

15 Lectures

SECTION-C

Quantum Dynamics: The equation of motion, Schrodinger picture, evolution of time development operator, Hamiltonian as generator of time evolution, Schrodingers equation of motion, Stationary states, Ehrenfest's theorm, Heisenberg picture, Heisenberg's equation of motion, interaction picture.

15 Lectures

SECTION-D

Identical Particles: Brief introduction to identical particles in quantum mechanics , Bosons and fermions, Slater determinants for correlated and uncorrelated systems, application to two particles in infinite square well, exchange forces, quantum statistical mechanics for distinguishable particles, bosons and fermions.

15 Lectures

M. Sc. Physics (Semester-I)
(Credit Based Evaluation & Grading System)

Text and Reference Books:

1. Quantum Mechanics, Volume 1 by Claude Cohen-Tannoudji , Bernard Diu , Frank Laloe
2. Modern Quantum Mechanics by J. J. Sakurai (Principal text)-Pearson Education Pvt. Ltd., New Delhi, 2002.
3. Introduction to Quantum Mechanics by David J. Griffiths, Prentice Hall, Inc., 1995
4. Quantum Mechanics by L I Schiff-Tokyo Mc Graw Hill, 1968.
5. Feynman lectures in Physics Vol. III-Addison Wesly, 1975.
6. Quantum Mechanics by Powel and Craseman-Narosa Publication, New Delhi, 1961
7. Quantum Mechanics by Merzbacher-John Wiley & Sons, New York, 1970.

M. Sc. Physics (Semester-II)
(Credit Based Evaluation & Grading System)

STATISTICAL MECHANICS

Course No. **LTP**
PHL-461 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Foundations of statistical mechanics; specification of states in a system, contact between statistics and thermodynamics, the classical ideal state, the entropy of mixing and Gibbs paradox. The phase space of a classical system, Liouville's theorem and its consequences.

15 Lectures

SECTION-B

The microcanonical ensemble with examples. The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations in the canonical ensemble. A system of harmonic oscillators. The statistics of paramagnetism. The grand canononical ensemble, the physical significance of the statistical quantities, examples, fluctuation of energy and density. Cluster expansion of classical gas, the virial equation of state.

15 Lectures

SECTION-C

Quantum states and phase space, the density matrix, statistics of various ensembles. Example of electrons in a magnetic field, a free particle in a box and a linear harmonic oscillator. Significance of Boltzamann formula in classical and quantum statistical mechanics.

15 Lectures

SECTION-D

An ideal gas in quantum mechanical microcanonical ensemble. Statistics of occupation numbers, concepts and thermodynamical behaviour of an ideal gas. Bose Einstein condensation. Discussion of a gas of photons and phonons. Thermodynamical behaviour of an ideal fermi gas, electron gas in metals, Pauli’s paramagnetism, statistical equilibrium of white dwarf stars.

15 Lectures

Text and Reference Books:

1. Statistical Mechanics:R.K. Patharia Butterworth-Heineman, 1996
2. Statistical Mechanics: Kerson Huang-Wiley-1963.

M. Sc. Physics (Semester-II)
(Credit Based Evaluation & Grading System)

ELECTRODYNAMICS-I

Course No. **LTP**
PHL-462 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80
Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

Lectures

SECTION-B

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.

Lectures

SECTION-C

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.

Lectures

SECTION-D

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.

Lectures

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.

M. Sc. Physics (Semester-II)
(Credit Based Evaluation & Grading System)

CONDENSED MATTER PHYSICS-I

Course No. **LTP**
PHL-463 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Diamagnetism and Paramagnetism: 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.

15 Lectures

SECTION-B

Ferromagnetism, Antiferromagnetism and Ferrimagnetism: Ferromagnetism, the Weiss molecular field, the interpretation of the Weiss field, Ferromagnetic domains, Bloch Wall, Spin Waves, quantization of spin waves, Thermal excitations of magnons. Neutron diffraction technique to study magnetic structure, Antiferromagnetism: The two sub lattice model, magnetic susceptibility of antiferromagnetic materials, superexchange interaction, the structure of ferrites, saturation magnetization, Neel's theory of ferrimagnetism, Curie temperature and susceptibility of ferrimagnets. 15 Lectures

SECTION-C

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

15 Lectures

SECTION-D

Lattice specific heat and Elastic Constants: The various theories of lattice specific heat of solids, Einstein model of the lattice specific heat. Density modes of vibration, Debye model of lattice specific heat, Born cut-off procedure, specific heat of metals, Elastic strain and stress components, Elastic compliance and stiffness constants, Elastic constants of cubic crystals, Elastic waves in cubic crystals. 15 Lectures

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. Elementary Solid State Physics-Omar-Addison Wesly, 1975.

M. Sc. Physics (Semester-II)
(Credit Based Evaluation & Grading System)

ATOMIC AND MOLECULAR SPECTROSCOPY

Course No.	**LTP**
PHL-464	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

Lectures

SECTION-B

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.

Lectures

SECTION-C

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.

Lectures

M. Sc. Physics (Semester-II)
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SECTION-D

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.

M. Sc. Physics (Semester-III)
(Credit Based Evaluation & Grading System)

QUANTUM MECHANICS-II

Course No.	**LTP**
PHL-451	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Perturbation Theory: First and second order perturbation theory for non-degenerate and degenerate systems. Simple harmonic oscillator using operator methods, Perturbation of an oscillator and Anharmonic oscillator, the variational 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.

Lectures

SECTION-B

Scattering theory: Born approximation, Validity of Born approximation for a square well potential. Optical theorem. Partial wave analysis, Determination of phase shift, applications to hard sphere scattering.

Lectures

SECTION-C

Relativistic Quantum Mechanics: Klein Gordon equation. Dirac Equation, covariance of Dirac equation. Plane wave solutions, Positive and negative energy solutions of Dirac equation, positrons. Properties of gamma matrices. Dirac spinors: spin and magnetic moment.

Lectures

SECTION-D

Angular Momentum algebra: Angular momentum commutation relations. Eigen vectors and eigen functions of J^2 and J_z. , Matrix elements of anular momentum operators, Addition of angular momentum and C.G. coefficients.

Lectures

M. Sc. Physics (Semester-III)
(Credit Based Evaluation & Grading System)

Text and Reference Books:

1. Modern Quantum Mechanics by J. J. Sakurai (Principal text)-Pearson Education Pvt. Ltd., New Delhi, 2002.
2. Introduction to Quantum Mechanics by David J. Griffiths, Prentice Hall, Inc., 1995
3. Quantum Mechanics by L I Schiff-Tokyo Mc Graw Hill, 1968.
4. Feynman lectures in Physics Vol. III-Addison Wesly, 1975.
5. Quantum Mechanics by Powel and Craseman-Narosa Publication, New Delhi, 1961
6. Quantum Mechanics by Merzbacher-John Wiley & Sons, New York, 1970.

M. Sc. Physics (Semester-III)
(Credit Based Evaluation & Grading System)

ELECTRODYNAMICS – II

Course No. **LTP**
PHL-452 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:

Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Wave Guides: Boundary Conditions at surface and within the conductor, Rectangular and cylindrical waveguides, modes in a rectangular wave guide, cut-off frequency and characteristic impedance, energy flow and attenuation in wave guides, Rectangular and Cylindrical resonant cavities, power loss in a cavity and quality factor.

15 Lectures

SECTION-B

Electrodynamics and Relativity: The special theory of Relativity, Einstein's Postulates, Geometry of relativity, Lorentz transformations, Structure of space-time, Relativistic Mechanics: Proper time and Proper velocity, Relativistic Energy and Momentum, Relativistic Kinematics and Dynamics. Relativistic Electrodynamics: Magnetism as a relativistic phenomenon, field tensor, electrodynamics in tensor notation and relativistic potentials.

15 Lectures

SECTION-C

Potentials and fields: Potential formulation, Scalar and vector potentials, Gauge Transformations, Coulomb and Lorentz Gauge, Continuous distributions, Retarded potentials, Jefimenko's Equations, Point charges, Lienard-Wiechert Potentials, potentials of a point charge moving with constant velocity, Fields of a moving point charge in arbitrary motion and uniform motion.

15 Lectures

SECTION-D

Radiation: Dipole radiation**,** Electric and Magnetic dipole radiation, Radiation resistance of the wire joining two ends of the dipole, Radiation from an arbitrary source, Radiated power from an accelera -ted charge at low velocities- Larmour-Power formula, Radiation reaction, Abraham Lorentz formula, Physical basis of the radiation reaction, centre fed linear antenna.

15 Lectures

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. 2012.
3. Classical Electromagnetic Radiation -J.B. Marion-Academic Press, New Delhi, 1995.

M. Sc. Physics (Semester-III)
(Credit Based Evaluation & Grading System)

CONDENSED MATTER PHYSICS-II

Course No.	**LTP**
PHL-456	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Defects 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.

15 Lectures

SECTION-B

Conductivity of Metals and ionic crystals: 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. 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.

15 Lectures

SECTION-C

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

15 Lectures

SECTION-D

Optical properties: Interaction of light with solids, Atomic and electronic interactions, Exciton absorption, Free carrier absorption, Absorption process involving impurities, Photoconductivity, Luminescence, excitation and emission, Decay mechanisms, Thallium activated alkali halides, Sulphide phosphors.

15 Lectures

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. Elementary Solid State Physics-Omar-Addison Wesly, 1975.

M. Sc. Physics (Semester-III)
(Credit Based Evaluation & Grading System)

NUCLEAR PHYSICS

Course No. **LTP**
PHL-457 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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.

15 Lectrues

SECTION-D

Multipole transitions in nuclei-Angular momentum and parity selection rules-Internal conversion-Nuclear isomerism, Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes, scattering matrix-Reciprocity theorem-Breit Wigner one level formula.

15 Lectures

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.

M. Sc. Physics (Semester-III)
(Credit Based Evaluation & Grading System)

Project

Course No.	**LTP**
PHD-573	**0 0 10**

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

PARTICLE PHYSICS

Course No. **LTP**
PHL-507 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80
Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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.

15 Lectures

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.

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

ADVANCED THEORETICAL TECHNIQUES

Course No. **LTP**
PHL-508 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80
Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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.

15 Lectures

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

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

EXPERIMENTAL METHODS

Course No.	**LTP**
PHL-581	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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).

15 Lectures

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

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.

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

MATERIAL SCIENCE

Course No.	**LTP**
PHL-584	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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).

15 Lectures

SECTION-D

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)

15 Lectures

M. Sc. Physics (Semester-III & IV)
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(ELECTIVE PAPERS)

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 (3^{rd} 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.

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

NANOTECHNOLOGY

Course No. **LTP**
PHL-585 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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.

15 Lectures

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

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.

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

RADIATION PHYSICS

Course No.	**LTP**
PHL-587	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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.

15 Lectures

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

Text and 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.

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

PLASMA PHYSICS

Course No.	**LTP**
PHL-588	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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

15 Lectures

Reference Books:

1. Introduction to Plasma Physics and Controlled Fusion: F F Chen, Second Edition-Springer, 1984
2. Plasma Physics: R.O. Dendy-Cambridge University Press, 1995.
3. Introduction to Plasma Physics: R J Goldston and P H Rutherford, Institute of Physics, 1995

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

QUANTUM COMPUTATION

Course No.	**LTP**
PHL-589	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A
Introduction to Quantum Information, Review of quantum mechanics, Review of linear algebra and quantum mechanics, Stern-Gerlach experiment, Quantum teleportation.

15 Lectures

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

15 Lectures

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

15 Lectures

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

15 Lectures

Text and Reference Books:

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.

M. Sc. Physics (Semester-III & IV)
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(ELECTIVE PAPERS)

COMPUTATIONAL METHODS

Course No. **LTP**
PHL-591 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80
Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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

15 Lectures

M. Sc. Physics (Semester-III & IV)
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(ELECTIVE PAPERS)

Text and Reference 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

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

Advanced Electronics

Course No. **LTP**
PHL-592 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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

15 Lectures

SECTION-B

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

15 Lectures

SECTION-C

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

15 Lectures

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.

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

FABRICATION OF ELECTRONIC DEVICES

Course No.	**LTP**
PHL-593	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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).

15 Lectures

SECTION-C

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.

15 Lectures

SECTION-D

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.

15 Lectures

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

Text and Reference 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

M. Sc. Physics (Semester-III & IV)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

ADVANCE STATISTICAL MECHANICS

Course No. **LTP**
PHL-594 **4 0 0**
Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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.

15 Lectures

SECTION-C

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

15 Lectures

SECTION-D

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.

15 Lectures

Test and Reference Books:

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

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Digital Signal Processing

Course No.	**LTP**
PHL-595	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

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.

15 Lectures

SECTION-B

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 method, correlation.

15 Lectures

SECTION-C

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 phase transformations.

15 Lectures

SECTION-D

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)

15 Lectures

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Text and References Books:

1. Digital Signal Processing - Alan V. Oppenhein and Ronald W. Schaffer - Prentice Hall Inc.- 2002
2. Digital Signal Processing - S Salivahanan, A. Vallavaraj and C Gnanapriya -Tata Mc Graw Hill-2000
3. Digital Signal Processing - S.K. Mitra- Tata Mc Graw Hill-2005
4. Digital Filter Designers Handbook - C.B. Rorabaugh- Mc Graw Hill-1993

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REACTOR PHYSICS

Course No.	**LTP**
PHL-596	**4 0 0**
Time: 3 Hours	**Max. Marks: 100**
	Mid Semester Marks : 20
	End Semester Marks : 80

Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Interaction of Neutrons with Matter in Bulk: Thermal neutron diffusion, Transport and diffusion equations, transport mean free path, solution of diffusion equation for a point source in an infinite medium and for an infinite plane source in a finite medium, extrapolation length and diffusion length-the albedo concept.

15 Lectures

SECTION-B

Moderation of Neutron: Mechanics of elastic scattering, energy distribution of thermal neutrons, average logarithmic energy decrement, slowing down power and moderating ratio of a medium, Slowing down density, slowing down time, Fast neutron diffusion and Fermi age theory, solution of age equation for a point source of fast neutrons in an infinite medium, slowing down length and Fermi age.

15 Lectures

SECTION-C

Theory of Homogeneous Bare Thermal and Heterogeneous Natural Uranium Reactors: Neutron cycle and mulplication factor, four factor formula, neutron leakage, typical calculations of critical size and composition in simple cases, the critical equation, material and geometrical uckling, effect of reflector.

Advantages and disadvantages of heterogeneous assemblies, various types of reactors with special reference to Indian reactors and a brief discussion of their design feature.

15 Lectures

SECTION-D

Power Reactors Problem of Reactor Control : Breeding ratio, breeding gain, doubling time, Fast breeder reactors, dual purpose reactors, concept of fusion reactors, Role of delayed neutrons and reactor period, Inhour formula, excess reactivity, temperature effects, fission product poisoning, use of coolants and control rods.

15 Lectures

Text and Reference Books:

1. Glasstone & Edlund : The Elements of Nuclear Reactor Theory-Van Nostrand, 1952.
2. Murray: Introductions of Nuclear Engineering-Prentice Hall, 1961.

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PHYSICS OF SEMICONDUCTORS AND DEVICES

Course No.	**LTP**
PHL-597	**3 1 0**

Time: 3 Hours **Max. Marks: 100**
Mid Semester Marks : 20
End Semester Marks : 80
Mid Semester Examination: 20% weightage
End Semester Examination: 80% weightage

Instructions for the Paper Setters:
Eight questions of equal marks (Specified in the syllabus) are to be set, two in each of the four Sections (A-D). Questions may be subdivided into parts (not exceeding four). Candidates are required to attempt five questions, selecting at least one question from each Section. The fifth question may be attempted from any Section.

SECTION-A

Semiconductor in equilibrium, charge carriers in semiconductors, dopants, intrinsic/extrinsic, degenerate semiconductors, statistics of donors and acceptors, charge neutrality, Fermi level and its variation with temperature, dopant density, carrier transport phenomena, drift, diffusion, graded impurity distribution, Einstein relation, non-equilibrium excess carriers in semiconductors, carriers generation-recombination 15 Lectures

SECTION-B

p-n junction, zero applied bias, built in potential, electric field, space charge width, forward and reverse bias, junction capacitance, abrupt junction (one sided junction), linearly graded junction, p-n junction current, ideal current voltage relationship, small signal model of p-n junction, diffusion resistance, reverse saturation current, forward bias recombination current, junction breakdown mechanisms (avalanche and Zener breakdown) 15 Lectures

SECTION-C

Schottky barrier diode (Ideal and non-ideal case), I-V relationship, comparison between Schottky and ideal p-n diode, Metal-semiconductor contacts (with n and p-type semiconductors), Bipolar transistor, basic operating principle, transistor current relations, modes of operations, amplification with BJT, minority carrier distribution, non-ideal effects, base width modulation, high injection, emitter band gap narrowing, current crowding 15 Lectures

SECTION-D

Two terminal MOS structure, energy band diagram, depletion layer thickness, workfunction difference, flatband voltage, threshold voltage, charge distribution, C-V characteristics, fixed oxide and interface charge effects. Basic MOSFET operation, MOSFET structure (n and p-type MOSFET), I-V relationship & its derivation, substrate bias effect, MOSFET scaling (qualitative idea), channel length modulation etc, optoelectronics devices (Solar cell, LED), operation and principle 15 Lectures

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Text and Reference Books:

1. Semiconductor Physics and Devices, Basic Principles, by Donald A Neamen, TMH Publication

2. Solid State Electronic Devices, Ben G Streetman, PHI Pvt Ltd

3. Physics of Semiconductor Devices, S.M. Sze, 2nd edition Wiley Publication

M. Sc. Physics (Semester-IV)
(Credit Based Evaluation & Grading System)

Advanced Experiments and Workshop

Course No.	**LTP**
PHP-572	**0 0 3**