FACULTY OF SCIENCES

SYLLABUS

FOR

M. Sc. Physics (CBCEGS)
(Semester: I - IV)

Examinations: 2019-20

GURU NANAK DEV UNIVERSITY
AMRITSAR

Note:  
(i)  Copy rights are reserved.
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(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

<table>
<thead>
<tr>
<th>Course No.</th>
<th>C/E/I</th>
<th>Course Title</th>
<th>Hrs/Week</th>
<th>LTP</th>
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<tbody>
<tr>
<td>PHL-401</td>
<td>C</td>
<td>Analog and Digital Electronics</td>
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<tr>
<td>PHL-412</td>
<td>C</td>
<td>Mathematical Physics</td>
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<tr>
<td>PHL-413</td>
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<td>Classical Mechanics</td>
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<td>PHL-414</td>
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<td>PHP-432</td>
<td>C</td>
<td>Electronics Lab</td>
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Total Credit 22

### Semester II

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<th>Course No.</th>
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<td>Spectroscopy Lab</td>
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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**

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## 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

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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  

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 and NAND gates, Boolean algebra, Demorgan’s theorems, Exclusive OR gate, Adder, Karnaugh maps, 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:
M. Sc. Physics (Semester-I)
(Credit Based Evaluation & Grading System)

MATHEMATICAL PHYSICS

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<td>Time: 3 Hours</td>
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<td>Mid Semester Examination: 20% weightage</td>
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<td>End Semester Examination: 80% weightage</td>
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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
Curvilinear coordinates, Differential vector operators in curvilinear 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

15 Lectures

Text and Reference Books:
2. Mathematical Physics : P.K. Chattopadhyay
M. Sc. Physics (Semester-I)  
(Credit Based Evaluation & Grading System)

CLASSICAL MECHANICS

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<th>Course No.</th>
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Time: 3 Hours

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

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:

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

QUANTUM MECHANICS-I

<table>
<thead>
<tr>
<th>Course No.</th>
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<td>Time: 3 Hours</td>
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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

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 observables, |r> and |p> representations.  
15 Lectures

SECTION-C

Quantum Dynamics: The equation of motion, Schrödinger picture, evolution of time development operator, Hamiltonian as generator of time evolution, Schrodinger's equation of motion, Stationary states, Ehrenfest’s theorem, 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
Text and Reference Books:

1. Quantum Mechanics, Volume 1 by Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe
6. Quantum Mechanics by Powel and Craseman-Narosa Publication, New Delhi, 1961
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 canonical 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 Boltzmann formula in classical and quantum statistical mechanics.

15 Lectures

SECTION-D

15 Lectures

Text and Reference Books:
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

Lectures

SECTION-B

Lectures

SECTION-C

Lectures

SECTION-D

Lectures
Text and Reference Books:

2. Introduction to Electrodynamics - D.J. Griffiths-Pearson Education Ltd.,
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


15 Lectures
Text and Reference Books:

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

ATOMIC AND MOLECULAR SPECTROSCOPY

Course No. PHL-464
LTP 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.

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.

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

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

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

QUANTUM MECHANICS-II

Course No. PHL-451  
LTP 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.

SECTION-B  

SECTION-C  

SECTION-D  
Angular Momentum algebra: Angular momentum commutation relations. Eigen vectors and eigen functions of $J^2$ and $J_z$. Matrix elements of angular momentum operators, Addition of angular momentum and C.G. coefficients.
Text and Reference Books:

2. Introduction to Quantum Mechanics by David J. Griffiths, Prentice Hall, Inc., 1995
5. Quantum Mechanics by Powel and Craseman-Narosa Publication, New Delhi, 1961
M. Sc. Physics (Semester-III)
(Credit Based Evaluation & Grading System)

ELECTRODYNAMICS – II

Course No. PHL-452

Time: 3 Hours

LTP 4 0 0

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


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 accelerated charged 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:
2. Introduction to Electrodynamics - D.J. Griffths-Pearson Education Ltd. 2012.
M. Sc. Physics (Semester-III)  
(Credit Based Evaluation & Grading System)

CONDENSED MATTER PHYSICS-II

Course No. PHL-456  
LTP 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
15 Lectures

SECTION-D
15 Lectures
Text and Reference Books:


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

NUCLEAR PHYSICS

<table>
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<tr>
<td>PHL-457</td>
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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, Deuteron 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

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 Lectures

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


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

**Project**

<table>
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# PARTICLE PHYSICS

**Course No.**

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<th>Course</th>
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**Time:** 3 Hours  

**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^0 - K^0 doublet unitary symmetry SU(2), SU (3) and the quark model.

15 Lectures

**SECTION-C**

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

ADVANCED THEORETICAL TECHNIQUES

<table>
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<td>Mid Semester Examination: 20% weightage</td>
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<td>End Semester Examination: 80% weightage</td>
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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 expansions, dirac delta function and generalized functions, direct approach for determining 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 eigenfunction 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

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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


15 Lectures

SECTION-B


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
Text and Reference Books:

1. Electronic Devices and Circuits: Jacob Milliman, C. Halkias
3. Techniques for Nuclear and Particle Physics Experiments: W.R. Leo.
5. Electronic Instrumentation and Measurements Techniques: William David Cooper.
M. Sc. Physics (Semester-III & IV)  
(Credit Based Evaluation & Grading System)  
(ELECTIVE PAPERS)  

MATERIAL SCIENCE

<table>
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## 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 refractories.

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)  
(Credit Based Evaluation & Grading System)  
(ELECTIVE PAPERS)  

Text and Reference Books:  
1. Thin Film Materials-Stress, defect, formation and surface evolution: L.B. Freund and S. Suresh- Cambridge,  
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
Text and Reference Books:

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

**RADIATION PHYSICS**

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<td>End Semester Marks : 80</td>
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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
Text and References Books:

2. Radiation Theory - Alison. P. Casart
PLASMA PHYSICS

Course No. PHL-588
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

15 Lectures

Reference Books:
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.  
PHL-589  
LTP  
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  
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:  
2. Quantum computing by Mika Hervensalo  
M. Sc. Physics (Semester-III & IV)  
(Credit Based Evaluation & Grading System)  
(ELECTIVE PAPERS)  

COMPUTATIONAL METHODS

Course No.  
PHL-591  

LTP  
4 0 0  

Mid Semester Marks : 20  
End Semester Marks : 80  

Max. Marks: 100  
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


15 Lectures

SECTION-B


15 Lectures

SECTION-C


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)
(Credit Based Evaluation & Grading System)
(ELECTIVE PAPERS)

Text and Reference Books:

3. Getting Started with MATLAB - Rudra Pratap-Oxford University Press-2005
M. Sc. Physics (Semester-III & IV)  
(Credit Based Evaluation & Grading System) 
(ELECTIVE PAPERS) 

Advanced Electronics

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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  
2. The P/C Microcontroller and Embedded systems- Using Assembly and C for PIC18  
M. Sc. Physics (Semester-III & IV)  
(Credit Based Evaluation & Grading System)  
(ELECTIVE PAPERS)

FABRICATION OF ELECTRONIC DEVICES

Course No.  
PHL-593  

LTP  
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:  

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
Text and Reference Books:

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

ADVANCE STATISTICAL MECHANICS

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

Time: 3 Hours

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

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.

15 Lectures

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

Test and Reference Books:
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

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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

15 Lectures

SECTION-C

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
Text and References Books:


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

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 muliplication 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:

PHYSICS OF SEMICONDUCTORS AND DEVICES

Course No. PHL-597

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
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

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

Advanced Experiments and Workshop

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