University of Rajasthan
Jaipur
SYLLABUS
M.SC.
(PHYSICS)
2015-2016 (I & II SEMESTER)
2016-2017 (III & IV SEMESTER)
Annexure III

University of Rajasthan, Jaipur
M.Sc. Physics Syllabus

Semester Scheme

1. Eligibility:
A candidate who has secured more than 55% or CGPA of 3.5 in the UGC Seven Point scale [45% or CGPA 2.5 in the UGC Seven Point Scale for SC/ST/Non-creamy layer OBC] or equivalent in the Bachelor degree in Science or Engineering or Technology shall be eligible for admission to First Semester of a Master of Science course. The admission shall be based on Entrance Examination as per syllabus to be notified by URATPG based on B.Sc. Physics Syllabus of University of Rajasthan. The M.Sc. Physics course in affiliated college will also be based on this syllabus and Semester System, Choice Based Credit System and Grade System as per Ord. 199F.

2. Scheme of Examination:

(1) Each theory paper EoSE shall carry 100 marks The EoSE will be of 3 hours duration. All questions will carry equal marks and will be compulsory. Five questions shall be set. First question will be comprising of five parts of short answer type with answer not exceeding half a page. Remaining four questions will be set with one from each of the unit. Second to Fifth question will have two parts, namely (A) and (B). Part (A) of Second to Fifth question shall be compulsory and Part (B) of these questions will have internal choice. The limit of answer will be five pages.

(2) Each Laboratory EoSE will be of four hour durations and involve laboratory experiments/exercises, and viva-voce examination with weightage in ratio of 75:25.
3. Course Structure:

The details of the courses with code, title and the credits assign are as given below.

Abbreviations Used

**Course Category**
CCC: Compulsory Core Course
ECC: Elective Core Course
OEC: Open Elective Course
SC: Supportive Course
SSC: Self Study Core Course
SEM: Seminar
PRJ: Project Work
RP: Research Publication

**Contact Hours**
L: Lecture
T: Tutorial
P: Practical or Other
S: Self Study

**Relative Weights**
IA: Internal Assessment (Attendance/Classroom Participation/Quiz/Home Assignment etc.)
ST: Sessional Test
EoSE: End of Semester Examination

The medium of instruction and examination shall be English only.
## First Semester

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Course Title</th>
<th>Course Category</th>
<th>Credit</th>
<th>Contact Hours Per week</th>
<th>EoSE Duration (Hrs.)</th>
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<td>1.</td>
<td>PHY 101</td>
<td>Classical Mechanics</td>
<td>CCC</td>
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<td>Classical Electrodynamics-I</td>
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<td>Mathematical Methods in Physics</td>
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<td>PHY 131</td>
<td>Seminar-1</td>
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<td>7.</td>
<td>PHY 111</td>
<td>Electronics Lab/ General Lab/ Spectroscopy Lab (Eight Experiments)</td>
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<td>8.</td>
<td>PHY 112</td>
<td>Computational Physics Programming in C</td>
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### Second Semester

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<td>Numerical Methods</td>
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<td>Numerical Methods Implementations using C Lab</td>
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<td>PHY 221</td>
<td>Summer Training Programme (Min. 4 weeks after II Semester EoSE)</td>
<td>PRJ</td>
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<td>Statistical and Solid State Physics</td>
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|            | Total        | 41                                      |
### Fourth Semester (Alternative)

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### Elective Core Courses:

**Specialization Clusters**
- A. AC: Astrophysics and Cosmology
- B. CMP: Condensed Matter Physics
- C. HEP: High Energy Physics
- D. EC: Electronic Communications
E. ES: Energy Studies
F. PP: Plasma Physics
G. ON: Advance Physics Open Electives

<table>
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<tr>
<th>Elective Course Code</th>
<th>Specialization</th>
<th>Paper Title</th>
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<tr>
<td>PHY A01</td>
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<td>PHY A02</td>
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<td>PHY A03</td>
<td>AC</td>
<td>General Theory of Relativity</td>
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<td>Quantum Gravity and Quantum Cosmology</td>
<td>PHY A04 OR PHY A03</td>
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<td>PHY A06</td>
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<td>Precision Tests in Astrophysics and Cosmology</td>
<td>PHY A01 or PHY A02 or PHY A04</td>
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<td>Physics Beyond Standard Model</td>
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<tr>
<td>PHY</td>
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Elective Core Courses Lab. Work will be based on Lab. Work of above papers wherever applicable.

The medium of instruction and examination shall be English only.

5. Course Details

PHY 101: CLASSICAL MECHANICS


Reference Books:
(1) Herbert Goldstein - Classical Mechanics, Narosa Publishing House
(2) Landau and Lifshitz - Classical Mechanics
(3) A. Raychoudhary - Classical Mechanics

PHY 102: QUANTUM MECHANICS

1. (a) States, Amplitude and Operators: States of a quantum mechanical system, representation of quantum-mechanical states, properties of quantum mechanical amplitude, operators and change of a state, a complete set of basis states, products of linear operators, language of quantum mechanics, postulates, essential definitions and commutation relations.

(b) Observables and Description of Quantum system: Process of measurement, expectation values, time dependence of quantum mechanical amplitude, observable with no classical analogue, spin dependence of quantum mechanical amplitude on position, the wave function, super position of amplitudes, identical particles.

2. Hamiltonian matrix and the time evolution of Quantum mechanical States: Permittivity of the Hamiltonian matrix, time independent perturbation of an arbitrary system, simple matrix examples of time independent perturbation, energy given states of a two state system, diagonalizing of energy matrix, time independent perturbation of two state system the perturbative solution: Weak field and Strong field cases, general description of two state system, Pauli matrices, Ammonia
molecule as an example of two state system.

3. Transition between stationary States: Transitions in a two state system, time dependent perturbations - The Golden Rule, Phase space, emission and absorption of radiation, induced dipole transition and spontaneous emission of radiation energy width of a quasi stationary state. The co-ordinate Representation: Compatible observables, quantum conditions and uncertainty relation, Coordinate representation of operators, position, momentum and angular momentum, time dependence of expectation values, The Ehrenfest Theorem, the time evolution of wave function, the Schrödinger equation, energy quantization, periodic potential as an example.

4. Symmetries and Angular Momentum:
   1. Compatible observables and constants of motion, symmetry transformation and conservation laws, invariance under space and time translations and space rotation and conservation of momentum, energy and angular momentum.
   2. Angular momentum operators and their Eigenvalues, matrix representations of the angular momentum operators and their eigenstates, coordinate representations of the orbital angular momentum operators and their eigenstate (Spherical Harmonics), composition of angular momenta, Clebsch-Gordon Coefficients tensor operators and Wigner Expart theorem, commutation relations, of $J_x, J_y, J_z$ with reduced tensor operator, matrix elements of vector operators, time reversal invariance and vanishing of static electric dipole moment of stationary state.

Reference Books:

2. P.A.M. Dirac, Quantum Mechanics.

**PHY 103: CLASSICAL ELECTRODYNAMICS**

1. Electrostatics: Electric field, Gauss Law, Differential form of Gaussian law. Another equation of electrostatics and the scalar potential, surface distribution of charges and dipoles and discontinuities in the electric field and potential, Poisson and Laplace equations, Green's Theorem, Uniqueness of the solution with the Dirichlet or Neumann boundary Conditions, Formal Solutions of electrostatic Boundary value problem with Green's function, Electrostatic potential energy and energy density, capacitance.

Boundary Value Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere, point charge in the presence of a charged insulated conducting sphere, point charge near a conducting sphere at a fixed potential, conducting sphere in a uniform electric field by method of images, Green function for the sphere, General solution for the potential, conducting sphere with hemispheres at a different potentials, orthogonal functions and expansion.

2. Multipoles, electrostatics of Macroscopic Media Dielectric: Multipole expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable


Reference Books:

1. J.D. Jackson: Classical Electrodynamics
2. Panofsky & Phillip: Classical electrodynamics and magnetism
3. Griffith: Introduction to Electrodynamics
4. Landau & Lifshitz: Classical Theory of Electrodynamics
5. Landau & Lifshitz: Electrodynamics of continuous media

PHY 104: MATHEMATICAL METHOD IN PHYSICS
1. Coordinates Transformation in N - dimensional space: Contravariant and
covariant tensor, Jacobian. Relative tensor, pseudo tensors (Example:
charge density, angular momentum) Algebra of tensors, Metric tensor,
Associated tensors, Riemann space (Example: Euclidean space and 4D
Minkowski space), Christoffel symbols, transformation of Christoffel
symbols, covariant differentiation, Ricci's theorem, divergence, Curl and
Laplacian tensor form, Stress and strain tensors, Hook's law in tensor
form. Expressing Maxwell equation, Klein Gordon and Dirac Equation,
in Lorentz covariant way.

2. Group of Transformation: (Example: Symmetry transformation of square)
Generators of a finite group, Normal subgroup, Direct product of groups,
Isomorphism and Homomorphism. Representation theorem of finite
groups, Invariants subspace and reducible representations, irreducible
representation, crystallographic point groups, Irreducible representation
of C₄ᵥ. Translation group and the reciprocal lattice.

3. Fourier Transforms: Development of the Fourier integral from the Fourier
Series, Fourier and inverse Fourier transform: Simple Applications: Finite
wave train, Wave train with Gaussian amplitude, Fourier transform of
derivatives, solution of wave equation as an application. Convolution
theorem. Intensity in terms of spectral density for quasi monochromic EM
Waves, Momentum representation, Application of Fourier transform to
diffraction theory: diffraction pattern of one and two slits.

4. Laplace transforms and their properties, Laplace transform of derivatives
and integrals, derivatives and integral of Laplace transform. Convolution
theorem. Impulsive function, Application of Laplace transform in solving
linear, differential equations with constant coefficient with variable
coefficient and linear partial differential equation.
Reference books:

3. Mathematical Methods - Potter and Goldberg (Prentice Hall of India)
4. Elements of Group Theory for Physicists: A.W. Joshi (Wiley Eastern Ltd.)
5. Vector Analysis (Schaum Series) (McGraw Hill)

PHY 105: Computer Programming

1. Basic concepts of programming languages: Programming domains, language evaluation criterion and language categories. Describing Syntax and Semantics, formal methods of describing syntax, recursive descent parsing, attribute grammars, dynamic semantics. Names, Variables, Binding, Type checking, Scope and lifetime.

2. Data types, array types, record types, union types, set types and pointer types, arithmetic expressions, type conversions, relational and Boolean expressions, assignment statements, mixed mode assignment, Statement level control structures, compound statements, selection statement, iterative statements, unconditional branching, guarded commands. fundamentals of sub-program, design issues, parameter passing methods, overloaded subprograms, generic subprograms, separate and independent compilation, design issues for functions, accessing nonlocal environment, user defined overloaded operators, implementing subprograms, blocks, implementing dynamic scooping.

3. Programming in C: Character set, variables and constants, keywords, Instructions, assignment statements, arithmetic expression, comment
statements, simple input and output, Boolean expressions, Relational operators, logical operators, control structures, decision control structure, loop control structure, case control structure, functions, subroutines, scope and lifetime of identifiers, parameter passing mechanism,


Recommended reference books:


PHY 111 / PHY 211 Electronics Lab/ General Lab/ Spectroscopy Lab

Experiments

1. To design a single stage amplifier of a given voltage gain and lower cut of frequencies.
2. To determine Lo. Co. and Rf of a given coil and to study the variations of Rf with frequency.
3. To design a RC coupled two stage amplifier of a given gain and the cutoff frequencies.
4. To study Hartley oscillator.
5. To Study Transistor bias Stability.
6. To design a Multivibrator of given frequency and study its wave shape.
7. To study the characteristics of FET and use it 0 design an relaxation
8. To study the characteristics of an operational amplifier.
9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure its frequency.
10. To study the addition, integration and differentiation properties of an operational amplifier.
11. To determine Rydberg constant using Hydrogen discharge tube and spectrometers.
12. To determine optical band gap of CdS thin film using Ocean optical spectrometer.
13. To determine Magnetostriiction of unknown material using Michelson interferometer.
14. To verify Fresnel's formula.
15. To study the percentage regulation and variation of Ripple factor, with load for a full wave rectifier.
16. To study analog to digital and digital to analog conversion.
17. To study a driven mechanical oscillator, frequency response with mass variation.
   (a) Amplitude response with frequency.
   (b) Phase lag between driven and driver.
18. To verify Hartmann's formula using constant deviation spectrograph.
19. To find e/m of electron using Zeeman effect.
20. To find Dissociation energy of Iodine
21. Study of CH Bands.
22. Salt Analysis / Raman effect (Atomic).
23. Design and study of pass filters.
24. Michelson Interferometer.
25. Fabry parot Interferometer.
27. Study of Elliptically polarised light by Babinet Compensator.
28. Verification of Cauchey's Dispersion relation.
29. Study of DC gate control characteristics and Anode current characteristics of SCR.

PHY 112: Computational Physics Programming in C
Write program in C Programming Languages based on course of PHY 105 and involving computations relevant to Physics.

PHY 201: ELECTRONICS


2. Oscillators and wave shaping Circuits: Oscillator Principle, Frequency stability response, the phase shift oscillator, Wein bridge oscillator, LC tunable oscillators, Multivibrators- Monostable, astable and bistable, Comparators, Square wave and triangle wave generation, clamping and clipping circuits.

3. Digital Electronics: Combinational logic: Standard representations for logic functions, Karnaugh Map Representation of logical functions, Simplification of logical functions using K-Map, Minimization of Logical...
functions specified in Minterms / Maxterms or truth table, Don’t care conditions, Adder (half and full), Subtractor (half and full), comparator, Multiplexers and their uses, Demultiplexer / Decoders and their uses. BCD arithmetics, Parity generators / Checkers, Code Converters, Priority Encoders, Decoder / Drivers for display devices, Seven Segment display device. ROM, Programmable Logic Array. Basic concepts about fabrication and characteristics of integrated circuits.

4. **Sequential Logic:** Flip-Flops: one - bit memory, RS, JK, JK master slave, T and D type flip flops, shift resisters - synchronous and asynchronous counters, cascade counters, Binary counter, Decade counter. A/D and D/A conversion- Basic principles, circuitry and simple applications. Voltage regulators - fixed regulators, adjustable voltage regulators, switching regulators. Basic idea of IC 555 and its applications as multivibrator and square wave generator. Opto-electronic Devices: Photo diode, Phototransistor, Light emitting Diode and their applications

**Text and Reference Books:**


**PHY 202 : ATOMIC AND MOLECULAR PHYSICS**

1. Gross structure of energy spectrum of hydrogen atom. Non degenerate first order perturbation method, relativistic correction to energy levels of an atom, atom in a weak uniform external electric field – first and second order Stark effect, calculation of the polarizability of the
ground state of hydrogen atom and of an isotropic harmonic oscillator; degenerate stationary state perturbation theory, linear Stark effect for hydrogen atom levels, inclusion of spin orbit interaction and weak magnetic field, Zeeman effect, effect of strong magnetic field. Magnetic dipole interaction, hyperfine structure and Lamb shift (only qualitative description).


Reference Books:
1. G. Banewell – Atomic and Molecular spectroscopy
2. Christopher J. Foot – Atomic Physics, Oxford Master series, 2005
8. Herzberg- Molecular spectra.

PHY 203 CLASSICAL ELECTRODYNAMICS –II

1. Plane Electromagnetic Waves and Wave Equation: Plane wave in a nonconducting medium. Frequency dispersion characteristics of dielectrics, conductors and plasma, waves in a conducting or dissipative medium, superposition of waves in one dimension, group velocity, casualty connection between D and E. Kramers-Kroning relation.
3. Covariant Form of Electrdynamic Equations: Mathematical properties of the space-time special relativity, Invariance of electric charge covariance of electrodynamics. Transformation of electromagnetic field. Radiation by moving charges : Lienard-Wiechert Potential for a point
charge. Total power radiated by an accelerated charge: Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion. Distribution in frequency and angle of energy radiated by accelerated charges, Thomson scattering and radiation, Scattering by quasifree charges, coherent and incoherent scattering, Cherenkov radiation.

4. Radiation damping, self fields of a particle, scattering and absorption of radiation by a bound system; Introductory considerations, Radiative reaction force from conservation of energy, Abraham Lorentz evaluation of the self force, difficulties with Abraham Lorentz model, Integro-differential equation of motion including radiation damping, Line Breadth and level shift of an oscillator, Scattering and absorption of radiation by an oscillator, Energy transfer to a harmonically bound charge.

Reference Books:

1. Classical Electrodynamics: Jackson
3. Introduction to Electrodynamics: Griffiths.
5. Electrodynamics of Continuous Media: Landau and Lifshitz.

PHY 204: NUMERICAL METHODS


4. Elementary probability theory, random variables, binomial, Poisson and normal distributions.

Reference:


PHY 111 / PHY 211 Electronics Lab/ General Lab/ Spectroscopy Lab

Experiments

1. To design a single stage amplifier of a given voltage gain and lower cut of frequencies.
2. To determine Lo, Co, and Rf of a given coil and to study the variations of Rf with frequency.
3. To design a RC coupled two stage amplifier of a given gain and the cutoff frequencies.
4. To study Hartley oscillator.
5. To Study Transistor bias Stability.
6. To design a Multivibrator of given frequency and study its wave shape.
7. To study the characteristics of FET and use it to design an relaxation oscillator and measure its frequency.
8. To study the characteristics of an operational amplifier.
9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure its frequency.
10. To study the addition, integration and differentiation properties of an operational amplifier.
11. To determine Rydberg constant using Hydrogen discharge tube and spectrometers.
12. To determine optical band gap of CdS thin film using Ocean optical spectrometer.
13. To determine Magnetostriction of unknown material using Michelson interferometer.
14. To verify Fresnel's formula;
15. To study the percentage regulation and variation of Ripple factor, with load for a full wave rectifier.
16. To study analog to digital and digital to analog conversion.
17. To study a driven mechanical oscillator; frequency response with mass variation
   (a) Amplitude response with frequency.
   (b) Phase lag between driven and driver.
18. To verify Hartmann's formula using constant deviation spectrograph.
19. To find e/m of electron using Zeeman effect.
20. To find Dissociation energy of Iodine
21. Study of CH Bands.
22. Salt Analysis / Raman effect (Atomic).
23. Design and study of pass filters.
24. Michelson Interferometer.
25. Fabry parot Interferometer.
27. Study of Elliptically polarised light by Babinet Compensator.
28. Verification of Cauchey's Dispersion relation.
29. Study of DC gate control characteristics and Anode current characteristics of SCR.

PHY 212: Numerical Methods Implementations using C Lab

Write program in C Programming Languages based on course of PHY 204 and involving computations relevant to Physics.

PHY 301: ADVANCED QUANTUM MECHANICS

1. Scattering (non-relativistic): Differential and total scattering cross section, transformation from CM frame to Lab frame, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, the optical theorem, Applications: scattering from a delta potential, square well potential and the hard sphere scattering of identical particles, energy dependence an resonance scattering, Breit-Wigner formula, quasi stationary states. The Lippman-Schwinger equation and the Green's functions approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in
elastic scattering.

2. Relativistic Formulation ad Dirac Equation: Attempt for relativistic formulation of quantum theory, the Klein-Gordon equation, probability density and probability current density, solution free particle K.G. equation in momentum representation, interpretation of negative probability density and negative energy solutions.

Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction). Solution of the free particle Dirac equation, orthogonality and completeness relations for Dirac spinors, interpretation of negative energy solution and hole theory.

3. Symmetries of Dirac Equation: Lorentz covariance of Dirac equation, proof of covariance and derivation of Lorentz boost and rotation matrices for Dirac spinors, Projection operators involving four momentum and spin, Parity (P), charge conjugation (C), time reversal (T) and CPT operators for Dirac spinors, Bilinear covariants, and their transformations, behaviour under Lorentz transformation, P,C,T and CPT, expectation values of coordinate and velocity involving only positive energy solutions and the associated problems, inclusion of negative energy solution, Zitterbewegung, Klein paradox.

4. The Quantum Theory of Radiation: Classical radiation field, transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillator, creation, annihilation and number operators, photon states, photon as a quantum mechanical excitations of the radiation field, fluctuations and the uncertainty relation, validity of the classical description, matrix element for emission and absorption, spontaneous emission in the dipole approximation.

Reference Books:

1. Ashok Das and A.C. Milissiones: Quantum Mechanics - A Modern
Approach (Garden and Breach Science Publishers).


4. J.J. Sakurai: Advanced Quantum Mechanics (John Wiley)

**PHY 302: STATISTICAL AND SOLID STATE PHYSICS**

1. Basic Principles, Canonical and Grand Canonical ensembles:
   Concept of statistical distribution, phase space, density of states
   Liouville's theorem, systems and ensemble, entropy in statistical
   mechanics Connection between thermodynamic and statistical quantities
   micro canonical ensemble, equation of state, specific heat and entropy of
   a perfect gas, using microcanonical ensemble.
   Canonical ensemble, thermodynamic functions for the canonical
   ensemble, calculation of means values, energy fluctuation in a gas, grand
   canonical ensemble, thermodynamic functions for the grand canonical
   ensemble, density fluctuations.

2. Partition functions and Statistics: Partition functions and properties,
   partition function for an ideal gas and calculation of thermodynamic
   quantities, Gibbs Paradox, validity of classical approximation,
   determination of translational, rotational an vibration contributions to the
   partition function of an ideal diatomic gas. Specific heat of a diatomic
   gas, ortho and para hydrogen.
   Identical particles and symmetry requirement, difficulties with Maxwell-
   Boltzmann statistics, quantum distribution functions, Bose Einstein and
   Fermi-Dirac statistics and Planck's formula, Bose Einstein condensation,
   liquid He4 as a Boson system, quantization of harmonic oscillator and
   creation and annihilation of phonon operators, quantization of fermion
operators.


Reference Books:

1. Huag: Statistical Mechanics
2. Reif: Fundamentals of Statistical and Thermodynamical Physics.

PHY 302: NUCLEAR PHYSICS-I

1. Two Nucleon system and Nuclear forces: General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, Central, noncentral and velocity dependent potential, Analysis of the ground state (3S1) of deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of deuteron under noncentral force, calculation of the electric quadrupole and magnetic dipole moments and the D-state admixture.

2. Nucleon-Nucleon Scattering and Potentials: partial wave analysis of the
neutron-proton scattering at low energy assuming central potential with square well shape, concept of the scattering length, coherent scattering of neutrons by protons in (ortho and para), hydrogen molecule; conclusions of these analyses regarding scattering lengths, range and depth of the potential; the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential; the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential; A qualitative discussion of proton-proton scattering at low energy; General features of two-body scattering at high energy effect of exchange forces. Phenomenological Hamada-Johnston hard core potential ad Reid hard core and soft core potentials; Main features of the One Boson Exchange Potentials (OBEP) no derivation.

3. Interaction of radiation and charged particle with matter (Not derivation): Law of absorption and attenuation coefficient photoelectric effect, Compton, scattering, pair production; Klein-Nishina cross sections for polarized and unpolarized radiation angular distribution of scattered photon and electrons, Energy loss of charged particles due to ionization, Bremstrahlung; energy target and projectile dependence of all three processes, Range-energy curves; Straggling.

4. Experimental Techniques: Gas filled counters; Scintillation counter; Cerenkov counters; Solid state detectors; Surface barrier detectors; Electronic circuits used with typical nuclear detector; Multiwire proportion chambers; Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron; Linear accelerators; Acceleration of heavy ions.

Reference Books


15. Harvey : introduction of Nuclear Physics and Chemistry.

PHY 311 / PHY 411 Advance Physics Laboratory Work

1. To determine half-life of a radio isotope using GM counter.
2. To study absorption of particles and determine range using at least two sources.
3. To study characteristics of a GM counter adn to study statistical nature of radioactive decay.
4. To study spectrum of beta- particles using Gamma ray spectrometer.
5. To calibrate a scintillation spectrometer and determine energy of g-rays from an unknown source.
6. (a) To study variation of energy resolution for a NaI (Tl) detector.
   (b) To determine attenuation coefficient (\( \mu \)) for rays from a given sources.
7. To study Compton scattering of gamma rays and verify the energy shift formula.
8. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using four probe method.
9. To study hall effect and to determine hall coefficient.
10. To study the variation of rigidity of a given specimen as a function of the temperature.
11. To study the dynamics of a lattice using electrical analog.
12. To study ESR and determine g-factor for a given spectrum.
13. To determine ultrasonic velocity and to obtain compressibility for a given liquid.
14. Study the characteristics of a given Klystron and calculate the mode number, E.T.S. and transit time.
15. Study the simulated L.C.R. Transmission line (audio frequency) and to find out the value for Zo experimentally from the graph.
16. Study the radiation pattern of a given Pyramidal horn by plotting it on a Polar graphy paper. Find the half power beam width and calculate its gain.
17. Find the dielectric constant of a given solid (Teflon) for three different lengths by using slotted section.
18. Find the dielectric constant of a given liquid (organic) using slotted section of X-band.
19. Verification of Bragg's law using microwaves.

**PHY 312: Elective Laboratory Work**

Laboratory work based on curriculum of elective papers taken in the semester.
PHY 401: INTRODUCTORY QUANTUM FIELD THEORY

1. Scalar and Vector fields, Classical Lagrangian field theory, Euler Lagrange's equation, Lagrangian density for electromagnetic field. Occupation number representation for simple harmonic oscillator, linear array of coupled oscillators, second quantization of identical bosons, second quantization of the real Klein-Gordon Field and Complex Klein-Gordon field, the meson propagator.

2. The occupation number representation for fermions, second quantization of the Dirac field, the fermion propagator, the em interaction and gauge invariance, covariant quantization of the free electromagnetic field, the photon propagator.

3. S-matrix, the S-matrix expansion, Wick's theorem, Diagrammatic representation in configuration space, the momentum representation, Feynman diagrams of basic processes, Feynman rules of QED.


Reference Books:

1. Quantum Field Theory by F. Mandal & G. Shaw (Honh-Wiley).

PHY 402: SOLID STATE PHYSICS

1. Lattice Dynamics and Optical Properties of Solids: Interatomic forces

2. Semiconductors: Law of mass action, calculation of impurity conductivity, ellipsoidal energy surfaces in Si and Ge, Hall effect, recombination mechanism, optical transitions and Schockely-Read theory, excitons, photoconductivity, photo-luminescence. Points line, planar and bulk defects, colour centres, F-centre and aggregate centres in alkali halides.


4. Superconductivity:

(a) Experimental Results: Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states, nuclear spin relaxation, Giaever and AC and DC Josephson tunnelling.

(b) Cooper pairs and derivation of BCS Hamiltonian, results of BCS Theory (no derivation).
Reference Books:


PHY 403: NUCLEAR PHYSICS-II

1. Nuclear Shell Model: Single particle and collective motions in nuclei: Assumptions and justification of the shell model, average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, magnetic dipole and electric quadrupole moments; and their comparison with experimental data; configuration mixing; single particle transition probability according to the shell model; selection rules; approximate estimates for the transition probability and Weisskopf units; Nuclear isomerism.

2. Collective Nuclear Models: Collective variable to describe the cooperative modes of nuclear motion; Parameterization of nuclear surface; A brief description of the collective model Hamiltonian (in the quadratic approximation); Vibrational modes of a spherical nucleus, Collective modes of a deformed even-even nucleus and moments of inertia; Collective spectra and electromagnetic transition in even nuclei and comparison with experimental data; Nilsson model for the single particle states in deformed nuclei.

3. Nuclear Gamma and Beta decay: Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations) Reduced transition probability, Selection rules; Internal conversion and zero-zero transition.
General characteristics of weak interaction; nuclear beta decay and lepton capture; electron energy spectrum and Fermi-Kurie plot; Fermi theory of beta decay (parity conserved selection rules Fermi and Gamow-Teller) for allowed transitions; ft-values; General interaction hamiltonian for beta decay with parity conserving and non conserving terms; Forbidden transitions; Experimental verification of parity violation; The V-A interaction and experimental verification.

4. Nuclear Reactions: Theories of Nuclear Reactions; Partial wave analysis of reaction Cross section; Compound nucleus formation and breakup; Resonance scattering and reaction-Breit-Wigner dispersion formula for s-waves \( I = 0 \), continuum cross section; Statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions; The optical model, Stripping and pick-up reactions and their simple theoretical description (Butler theory) using plane wave Born approximation (PWBA) Shortcomings of PWBA Nuclear structure studies with deuteron stripping \((d, p)\) reactions.

Reference Books:


PHY 311 / PHY 411 Advance Physics Laboratory Work

1. To determine half-life of a radio isotope using GM counter.
2. To study absorption of particles and determine range using at least two sources.
3. To study characteristics of a GM counter and to study statistical nature of radioactive decay.
4. To study spectrum of beta-particles using Gamma ray spectrometer.
5. To calibrate a scintillation spectrometer and determine energy of g-rays from an unknown source.
6. (a) To study variation of energy resolution for a NaI (Tl) detector.
(b) To determine attenuation coefficient (\(\mu\)) for rays from a given source.
7. To study Compton scattering of gamma rays and verify the energy shift formula.
8. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using four-probe method.
9. To study hall effect and to determine hall coefficient.
10. To study the variation of rigidity of a given specimen as a function of the temperature.
11. To study the dynamics of a lattice using electrical analog.
12. To study ESR and determine g-factor for a given spectrum.
13. To determine ultrasonic velocity and to obtain compressibility for a given liquid.
14. Study the characteristics of a given Klystron and calculate the
mode number, E.T.S. and transit time.
15. Study the simulated L.C.R. Transmission line (audio frequency) and to find out the value for a Zo experimentally from the graph.
16. Study the radiation pattern of a given Pyramidal horn by plotting it on a Polar graphy paper. Find the half power beam width and calculate its gain.
17. Find the dielectric constant of a given solid (Teflon) for three different lengths by using slotted section.
18. Find the dielectric constant of a given liquid (organic) using slotted section of X-band.
19. Verification of Bragg's law using microwaves.

**PHY 412 Elective Laboratory Work**
Laboratory work based on curriculum of elective papers taken in the semester.

**PHY A01: ASTROPHYSICS – I**

1. Astronomy fundamentals, Black body radiation, Radiation mechanism, Flux density and luminosity, basics of Radiative transfer and Radiative processes, Magnitudes, Motions and Distances of Stars: Absolute stellar magnitude and distance modulus, Bolometric and radiometric magnitudes, Colour-index and luminosities of stars,

2. Stellar positions and motions, Velocity dispersion, Statistical and moving cluster parallax, Extinction, Stellar temperature, Effective temperature, Brightness temperature, Color temperature, Kinetic temperature, Excitation temperature, Ionization temperature,
Spectral Classification of stars, Utility of stellar spectrum, stellar atmospheres.

3. Overview of the major contents of the universe, Sun and stars, stellar interiors, HR diagram, nuclear energy generation, neutrino astronomy, white dwarfs and neutron stars, plasma processes, compact objects, shape, size and contents of our galaxy

4. Basics of stellar dynamics, normal and active galaxies, gravitational wave astronomy, Newtonian cosmology, microwave background, early universe.

**Reference Books:**

3. Astrophysical Concepts : M.Harwit
4. An Introduction to Astrophysics : Baidyanath Basu
6. The Sun : An Introduction : M.Stix
7. Stellar Atmospheres : D.Mihalas
8. An Introduction to the Study of Stellar Structures : S.Chandrasekhar
9. Spherical Astronomy : W.M.Smart

**PHY A02: ASTROPHYSICS – II**

1. Coordinate systems, precession, time, heliocentric corrections; methods of observation, resolution, sensitivity, noise, quantum efficiency, spectral response, Johnson noise, signal to noise ratio, background, aberrations. 2.
2. Telescopes at different wavelengths, detectors at different wavelengths, imaging, spectroscopy, polarimetry, calibration, atmospheric effects at different wavelengths, active/adaptive optics, interferometry, speckle interferometry, aperture synthesis, methods of data reduction,

3. Fourier transforms, calibrations; neutrino astronomy, gravitational wave astronomy. Numerical techniques in physics and astrophysics, errors and error propagation, numerical integration and interpolation, random numbers, astrostatistics, probability distributions, hypothesis testing, sampling methods,


Reference Books:


PHYSICS A03: General Theory of Relativity

2. Bianchi identity and curvature tensor. Einstein’s field equation and gravitation. Schwarzschild metric and solutions of Einstein’s equation.

Reference Books:
1. S. Weinberg, Gravitation and Cosmology.
2. S. Carroll, General Relativity.

PHYSICS A04: Cosmology
2. Particle and the Nucleo-synthesis in the early Universe. Various phase transitions and time-line of the Universe.
3. Inflationary cosmology and generation of density perturbations.

PHY A05: Quantum Gravity and Quantum Cosmology
1. The need for a theory of Quantum Gravity and Quantum Cosmology. Physics at short distance. Big-Bang and Physics at Planck scale: Planck length, Planck time, Planck mass, and Planck energy.
3. Overview of diverse approaches to Quantum Gravity: Geometrodynamics; Loop Quantum Gravity and Loop Quantum Cosmology;

PHY A06: Precision Tests in Astrophysics and Cosmology
1. Recent experimental results on Cosmic Microwave Background Radiations. Results of WMAP experiments and COBE experiments.
2. The experimental evidence of dark matter and dark energy.
3. Gravitational Wave detectors. Super-Novae as standard candles
4. Precision experiments in Astrophysics and Cosmology.

PHY B01: Condensed Matter Physics-I

2. High temperature superconductors and GMR/CMR materials: High temperature superconductors, normal state properties (structural phase transition) of cuprates, phase separation and charge distribution into CuO2 planes, striped phase, phase diagram, pseudogap, dependence of Tc on crystal structure, effect of impurities. GMR/CMR materials, Ruddlesden-Popper series of perovskites. Onset of ferromagnetism and metallic conduction. Double exchange.
4. Structural characterization and electron structure determination: Basic theory of X-ray diffraction, indexing of Debye-Scherrer patterns from powder samples, examples from some cubic and non-cubic symmetries. Neutron
diffraction – basic interactions, cross section, scattering length and structure factor. Basic principles of X-ray absorption spectroscopy, photo emission and positron annihilation techniques. Qualitative discussion of experimental arrangement and of typical results for both simple as well as transition metals.

Books
4. Introduction to Polymer Physics by David. I. Bower.
5. Polymer Science by J.R. Fried.

PHY B02: Condensed Matter Physics-II


2. **Nanomaterials:** Free electron theory (qualitative idea), variation of density of states with energy, variation of density of state and band gap with size of crystal. Electron confinement in infinitely deep square well, confinement in two and one dimensional well, idea of quantum well structure, tunneling through potential barrier, quantum dots, quantum wires. Different methods of

3. Films and surfaces Study of surface topography by multiple beam interferometry, conditions for accurate determination of step height and film thicknesses (Fizeau fringes). Electrical conductivity of thin films, difference of behaviour of thin films from bulk material, Boltzman transport equation for a thin film (for diffuse scattering), expression for electrical conductivity for thin film. Enhancement of magnetic anisotropy due to surface pinning.

4. Experimental techniques Basic ideas of the techniques of field emission, scanning tunnelling and atomic force microscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction line broadening, small angle X-ray scattering and small angle neutron scattering.

Books

1. Tolansky: Multiple beam interferometry
2. Heavens: Thin films
3. Chopra: Physics of thin films
8. Nanostructures and nanomaterials: synthesis properties and applications by Guozhong Cao, Imperial College Press, 2004


11. Handbook of Nanostructured materials and nanotechnology

**PHY C01: High Energy Physics I**

1. Elementary particles and the fundamental forces. Quarks and leptons. The mediators of the electromagnetic, weak and strong interactions. Interaction of particles with matter; particle acceleration, and detection techniques. Symmetries and conservation laws.


Recommended books
1. Francis Halzen and Allan D. Martin, *Quarks and Leptons: An Introductory Course in Modern Particle Physics*, John Wiley and Sons
3. *The Review of Particle Physics*, (Particle Data Group)
4. David Griffiths, *Introduction to Elementary Particles*
5. Byron Roe *Particle Physics at the New Millennium*
6. Donald Perkin, *Introduction to high energy physics*.
7. Martin and Shaw, *Particle Physics*

**PHY C02: High Energy Physics II**

2. QCD: Electron positron annihilation into hadrons, heavy quark production, three jet events, QCD corrections, Perturbative QCD, Drell-Yan process
3. Weak Interactions: Parity violation, V-A form of weak interaction, Nuclear beta decay, muon decay, pion decay, charged current neutrino electron scattering, neutrino quark scattering, weak neutral currents, the Cabibo angle, weak mixing angles, CP invariance.
4. Gauge Symmetries: U(1) Local gauge invariance and QED, Non-abelian gauge invariance and QCD, massive gauge bosons, spontaneous breakdown of symmetry, the Higgs mechanism.

Recommended books

1. Francis Halzen and Allan D. Martin, *Quarks and Leptons: An Introductory Course in Modern Particle Physics*, John Wiley and Sons
3. The Review of Particle Physics, (Particle Data Group
4. David Griffiths, Introduction to Elementary Particles
5. Byron Roe Particle Physics at the New Millennium
7. Martin and Shaw, Particle Physics

PHY C02: High Energy Physics III

2. Unified models of weak and electromagnetic interactions Standard Model, flavor group, flavor-changing neutral currents. Weak isospin.
3. Quark and lepton mixing. CP violation. Neutrino oscillations. CKM quark mixing matrix, GIM mechanism, rare processes, neutrino masses, seesaw mechanism
4. QCD confinement and chiral symmetry breaking, instantons, strong CP problem

Recommended books

1. Francis Halzen and Allan D. Martin, Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley and Sons
3. Particle Data Group, The Review of Particle Physics,
4. David Griffiths, Introduction to Elementary Particles
5. Byron Roe Particle Physics at the New Millennium
7. Martin and Shaw, Particle Physics
PHY C04: Renormalization
1. Theory of renormalization. The renormalization group and applications to the theory of phase transitions.
3. Applications of the renormalization group of quantum chromodynamics.

PHY C05: Supersymmetry
1. Grand unification, gauge coupling unification, proton decay;
2. Naturalness and the hierarchy problem; technicolor;
3. The supersymmetric Standard Model, supersymmetric unification,
4. SUSY dark matter, SUSY flavor problem.

PHY C05: Physics Beyond the Standard Model
1. Introduction to general relativity, and Curvature, energy-momentum tensor, Einstein field equations.
2. Evolution of the Universe based on the theory of general relativity.
3. Test of the models and the nature of dark matter and dark energy.
4. TeV scale gravity; the cosmological constant problem, Large extra dimensions.

PHY - D01: Electronics and Communication I

UNIT I

Waveguides and components:
Field distribution in rectangular waveguide in TE and TM modes, Phase velocity, Group velocity, Characteristics impedance, wall current, Cavity resonators and their excitation techniques, Scattering matrix for Microwave Tees and hybrid junction directional coupler, Construction and working of precision attenuator and phase shifter.
UNIT II

Solid State MW Devices:
Avalanche Transit Time Devices: Read diode, Negative resistance of an avalanching p-n junction diode, Transferred Electron Devices: Gunn effect, two valley model, High field domains, Different modes for microwave generation
Parametric Devices: Varactor, Nonlinear reactance and Manley- Rowe power relations, Parametric Up-converter amplifier and its Noise properties

Unit -III

Conventional microwave sources and Antennas:
Construction and working of two cavity Klystron and Reflex klystron and their efficiency.
Magnetron and its operating characteristics, Hull cut-off condition.
Traveling wave tubes: Construction and working and Introduction to Gyratron Antenna parameters, Huygen source, Electromagnetic horn antenna.
Introduction to microstrip patch antennas and array antennas

Unit-IV: Measurements techniques:
Microwave Measurements: Power, frequency, attenuation and VSWR measurements, Return loss measurement, Concept of Smith chart and its use in impedance measurement, Microwave antenna measurement, measurement of dielectric properties of a solid materials using wave guide method.
Measurement devices: Digital voltmeter- ramp type and integrating type, Bolometers, Power Meter, VNA

Reference Books:
3. Microwave Devices and Circuits: L.S.Y. Liao, PHI
4. Antenna Theory and Design: C.A. Balanis, John Wiley & Sons

PHY- D02: Electronics and Communication II

UNIT I

Power Electronics:
Characteristic of power diodes, power transistor, TRIAC, DIAC. SCR: Construction and its characteristics, simple firing circuit using UJT. Controlled rectifiers: Single and Three phase half wave and full wave controlled rectifiers. Commutation Circuits: Line commutation and different commutation circuits, Inverters: Single phase Tapped and Bridge inverter circuits, Basic chopper circuits, 2 and 4 quadrant choppers. Principle of operation of cycloconverter.

UNIT II

MW Propagation

Microwave communication: LOS microwave system, derivation of communication range, OTH microwave systems, derivation of field strength of troposphere waves. Introduction to satellite and mobile communication, RADAR.

Unit-III

Communication Electronics:
Introduction to signals: Size, classification, signal operations, unit signal functions, orthogonality, correlation, trigonometric Fourier series, exponential Fourier series.
Analysis and transmission of signals, Aperiodic signal representation by fourier integral, fourier transforms of unit functions, scaling property, time shifting property, frequency shifting property, bandwidth,

Unit-IV

Amplitude modulation: Double-sideband suppressed carrier (DSBSC) modulation and demodulation, Generation of DSBSC waves, coherent detection of DSBSC waves, SSB amplitude modulation and demodulation, Generation and detection of SSB waves. Vestigial sideband modulation. Frequency division multiplexing (FDM).

Angle Modulation: Concept of instantaneous frequency, generalized concept of angle modulation, bandwidths, Wide-band FM, generation of FM waves, Demodulators, Fm receiver.

Reference Books:


**PHY D03: Microwave Electronics and Applications**

1. **CIRCUIT THEORY OF WAVE GUIDES:** Power Transmission in Wave Guides, Equivalent Voltages and Currents, Impedance Description of Wave Guide Elements and Circuits, Foster’s Reaction Theorem, One Port Circuits, N-Ports Circuits, Scattering Matrix Formulation, Excitation and Coupling of Wave Guides, Dielectric Loaded Wave Guides, Surface Wave Guides.


3. **APPLICATIONS OF MICROWAVES:** Applications of Microwave in RADAR, Satellite Communication, Mobile Communication, Microwave Heating.

4. **FERRITES** Microwave Propagation in Ferrites, Nano Ferrites, Synthesis of Nano Ferrites, Dielectric Properties of Ferrites, Ferrites as a Microwave Absorbers.

**PHY D04: Satellite Communications and Remote Sensing**

1. Principle of Satellite Communication: General and Technical characteristics, Active and Passive satellites, Modem and Codec. Communication Satellite Link Design: General link design equation, Atmospheric and Ionospheric effect on link design, Earth station parameters.


Reference Books:

PHY E01: ENERGY STUDIES –I

recombination of carriers.

2. Types of Solar Cells, p n junction solar cell, Transport Equation, Current Density, Iopen circuit voltage and short circuit current, Brief descriptions of single crystal silicon and amorphous silicon solar cells, elementary ideas of advanced solar cells e.g. Tandem Solar Cells, solid Liquid Junction Solar Cells, Nature of Semiconductor, Electrolyte Junction, Principles of Photoelectrochemical solar Cells.


4. Safety and Utilisation of Hydrogen : Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Fuel Cells, Elementary concepts of other Hydrogen Based devices such as Air Conditioners and Hydride Batteries.


Text and Reference Books


References:
   Rohsenow, James P. Harnou and Fjup N. Ganic.
5. Thermal conductivity of Solids: J.F. Parrot and Audrey D. Stuckers:
   Pion Limited, London.
   New York.

PHY F01: PLASMA PHYSICS-I
1. Basic properties and occurrence. Definition of plasma. Criteria for plasma
   behaviour, Plasma oscillation. Quasi-neutrality and Debye Shielding. The
   Plasma in Magnetosphere and ionosphere. Plasma production and
diagnostics. Thermal ionization. Saha equation. Brief discussion of
   methods of laboratory plasma production. Steady stage glow discharge,
   microwave breakdown and induction discharge, Double Plasma Machine.
   Elementary ideas about plasma diagnostics. Electrostatic and magnetic
   probes.
2. Charged particle motion and drifts, Guiding centre motion of a charges
   particle. Motion in (i) uniform electric and magnetic field (i) gravitational
   and magnetic fields. Motion in non-uniform magnetic field (i) grad B
   perpendicular to B, grad B drift and curvature drift (ii) grade B parallel to
   B and principle of magnetic mirror. Motion in non-uniform electric field

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Asst. Registrar (Acad.)
University of Rajasthan
for small Larmour radius. Time varying electric field and polarization drift. Time varying magnetic field adiabatic invariance of magnetic moment.

3. Plasma fluid equations fluid equations; Conventive, Two fluid and single fluid equations. Fluid drifts perpendicular to B diamagnetic drift.


References:

**PHY F02: PLASMA PHYSICS-II**

Electromagnetic waves parallel to magnetic field, Hydromagnetic waves. Magnetosonic waves.


References:

UNIT I: Generic Methodologies for Nanotechnology

Introduction and classification, What is nanotechnology? Classification of nanostructures: Nanoscale architecture; The free electron model and energy bands, Crystalline solids, Periodicity of crystal lattices, Electronic conduction; Effects of the nanometer length scale, Changes to the system total energy, Changes to the system structure, How nanoscale dimensions affect properties.

UNIT - II Nanodimensional Materials

0D, 1D, 2D structures, Size Effects, Fraction of Surface Atoms, specific Surface Energy and Surface Stress, Effect on the Lattice Parameter, Phonon Density of States, the General Methods available for the Synthesis of Nanostructures, precipitative, reactive, hydrothermal/ solvothermal methods, suitability of such methods for scaling, potential Uses

UNIT - III Physical and Chemical Methods of Nanostructured Materials

Thermal evaporation, Pulsed Laser Deposition (PLD), DC/RF Magnetron Sputtering, Molecular Beam Epitaxy (MBE), Inert Gas Condensation Technique (IGCT),


UNIT - IV Specific Features of Nanoscale Growth

Thermodynamics of Phase Transitions, triggering the Phase Transition, fundamentals of nucleation growth, Controlling Nucleation & Growth, Size Control of the Nanometric State, Aggregation, Stability of Colloidal, Dispersions, Spontaneous Condensation of Nanoparticles: Homogeneous Nucleation, Spinodal decomposition, Other undesirable Post-Condensation Effects, Nanoparticles’ morphology

References:

PHY G02 : Nanotechnology-II

UNIT - I Nanoscale Properties - I

Magnetism: Magnetic Moment in clusters or Nanoparticles, Magnetic Order, coercivity, Magneto-crystalline Anisotropy, thermal activation and Super-paramagnetic effects.

Electronics and Optoelectronics: Quantum Confinement of Super lattices and Quantum Wells, Doping of a Nanoparticles, Excitonic Binding and Recombination Energies, Capacitance in a Nanoparticle.

UNIT – II Nanoscale properties - II

Diffusion in Nanocrystalline Materials: Diffusion In Grain Boundaries Of Metals, Nanocrystalline Ceramics, Correlation Between Diffusion and Crystallite Growth, Other properties: brief overview of optical properties, mechanical properties including superplasticity phenomena, reactivity of nanoparticles.

UNIT-III Characterization Methods


UNIT – IV Nanotechnology in energy conservation and storage
Nanotechnology for sustainable energy: Energy conversion process, indirect and direct energy conversion, Materials for light emitting diodes, batteries, advanced turbines, catalytic reactors, capacitors, fuel cells.

Energy challenges, development and implementation of renewable energy technologies, nanotechnology enabled renewable energy technologies, Energy transport, conversion and storage: Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition.

References:

PHY Z01: LASERS AND LASER APPLICATIONS

Basic Principle and Different Lasers:
Principle and Working of CO2 laser and Qualitative Description of Longitudinal and TE laser systems. Threshold condition for Oscillation in Semiconductor Laser. Homostructure and Heterostructure p–n junction lasers,
Non Linear Processes:
Novel Applications of Laser:
Cooling and Trapping of Atoms, Principles of Doppler and Polarization Gradient Cooling, Qualitative Description of Ion Traps, Optical Traps and Magneto-Optical Traps, Evaporative Cooling and Bose Condensation.
Spectroscopic Techniques:
Laser as a source of radiation and its characteristics, Laser fluorescence and absorption spectroscopy, Multiphoton ionization and separation of isotopes.

Reference Books:
1. Spectroscopy Volume 1, 2 and 3: B.P. Straughan and S. Walker.

PHY Z02 Reactor Physics - I

Neutron Transport behaviour-Neutron Transport Concept, Neutron Diffusion theory, Diffusion in multiplying systems, the slowing down of neutrons, slowing down in infinite media

Reference:

2. Introduction to Nuclear Engineering – John R. Larmorsh
3. Fundamentals of Nuclear Reactor Physics – Elmer E. Lewis

**PHY Z03 Reactor Physics – II**


Reference:

2. Introduction to Nuclear Engineering – John R. Larmorsh
3. Fundamentals of Nuclear Reactor Physics – Elmer E. Lewis

**PHY- Z04: Health Physics-I**

1. Radiation sources:

2. Radiation Dosimetry:

Radiation quantities: KERMA, fluence, relation of KERMA with photon fluence and neutron fluence, Radiation dose, unit, absorbed dose, equivalent dose, whole body dose, exposure: definition, unit, relation between exposure to energy fluence, exposure rate, internal and external exposure, exposure measurement-free air chamber, air wall chamber, exposure-dose relationship, absorbed dose measurement (Bragg-gray principle), gamma dose calculation, beta dose calculation, skin dose calculation-surface dose, submersion dose, volume dose, ICRP methodology, effective dose, committed dose.

3. Dosimetry and calibration:

Definition, calibration types, classification of calibration laboratories, Absolute cavity ion chamber, calibration of ion chamber using X-rays/gamma rays, calibration of photon beams with exposure-calibrated ion chamber, calibration of photon beams in phantom, calibration of electron beams in phantom.

4. Biological Effects of Ionizing Radiations & Risk Models:

Biological basis for radiation safety, effect of radiation, deterministic and stochastic effects, chronic exposure and acute

References:

1. Introduction to health Physics, Herman cember and Thomas E. Johnson, 4th edition.

2. Interaction to radiological physics and radiation dosimetry, Frank Herbert Attix,WILEY_VCH verlag GmbH &Co KGaA

3. AERB SAFETY GUIDE NO.AERB/SG/G-8

4. Atomic Energy (Radiation Protection) Rules, 2004


PHY-Z05: Health Physics-II

1. Standards, Regulations and safety

Regulatory bodies: ICRP, AERB, NRC, IAEA ,NEA and their comparison, philosophy of radiation safety, dose limitation systems-AERB and ICRP, ICRP basic radiation safety criteria, dose coefficient, annual limit of intake (ALI)-ICRP, and AERB, regulation on radian practices, radiation safety procedure,ICRP-30 and 60 criteria, lung model, ICRP-66 human respiratory tract model, Derived air concentration (DAC), uptake calculation, internal radiation safety and external radiator safety, Atomic Energy (Radiation Protection) Rules, 2004, Annual report of AERB.
2. Health Physics Instrumentation:

Radiation detectors, Gas filled detectors: GM tube detector, ion chamber, proportional counter, BF3 detector, scintillation detectors: NaI, CsI, semiconductor detectors, Dose measuring instruments and devices: personnel monitoring, pocket dosimeters, TLD dosimeter, film badge dosimeters, neutron dosimeters, electronic dosimeters, Survey meters, MDA of instruments, reliability of instruments, calibration of instruments, calibration facility in India, contamination monitor, criteria for choosing monitors, survey meters, dosimeters. Non-ionizing radiation safety.

3. Radioactive waste management:

Radioactive waste, classification of waste-half life, activity, handling of radioactive source and waste, transportation of waste, TREM card, safe disposal of radioactive waste, classification of waste disposal sites, monitoring of radioactive disposal site.

4. Radiation Emergency:

Radiation emergency definition, its classification, measurable quantities in emergency, declaration, termination, radiation emergency reporting authorities, formats, handling procedures, interventional level, averted dose, emergency instruments, radiation safety in emergency, contamination, control on contamination spread.

References:

1. Introduction to health Physics, Herman cember and Thomas E. Johnson, 4th edition.
2. Interaction to radiological physics and radiation dosimetry,
   Frank Herbert Attix, WILEY_VCH verlag GmbH & Co
   KGaA.


4. Atomic Energy (Radiation Protection) Rules, 2004

5. Atomic Energy (Safe Disposal of Radioactive Wastes)
   Rules, 1987

ICRP reports.

6. Nuclear Reactor Engineering (Reactor Design and Basics)
   – Samuel Glasstone & Alexander Sessonske.

**PHY Z06 Computational Physics – I**

Errors & Uncertainties in Computations, Monte Carlo Methods,
Random Numbers, Probability distribution functions, Improved
Monte Carlo Integration, Random walks and the Metropolis
algorithm, Monte Carlo methods in statistical physics

**Reference:**

1. Computational Physics – M. Jensen
2. Computational Physics – Steven E. koonin
   Jose Paez, C. Bordeianu

**PHY Z07 Computational Physics – II**

Quantum Monte Carlo Methods- Variational Monte carlo for quantum
mechanical systems, Simulation of molecular systems, Many body systems
Simulating matter with molecular dynamics, Molecular dynamics, verlet and velocity-verlet algorithm, 1-D implementation, Trajectory analysis

Reference:
1. Computational Physics – M. Jensen
2. Computational Physics – Steven E. koonin

PHY Z08: LASER-I

1. Interaction of radiation with matter: Absorption, spontaneous and stimulated emission, Einstein’s Coefficients, population inversion, metastable states, gain, absorption coefficient, stimulated cross section, threshold condition. Two level system (Ammonia maser-Physical separation of excited species from those in ground state). Three and Four level system, Rate equations for three and four level system, threshold pump power, relative merits and de-merits of three and four level system.

2. Optical resonators: Resonator configurations, Stability of resonators, Characteristics of Gaussian beam, Transverse and longitudinal modes, mode selection techniques (at least two techniques in each case), losses in a resonator, Hardware design-laser support structure, mirror mounts, optical coating etc.

3. Gas and dye lasers: excitation in gas discharge, collisions of 1st and 2nd kind, electron impact excitation-its cross section, different types of gas lasers: He-Ne, N2, CO2, Metal vapour lasers, Excimer and chemical laser, dye laser.

4. Laser Parameters and their measurement: Near field and Far field regimes, Internal and external parameters in the near and far field, Detectors and their operational mechanism including specific properties like rise time,
spectral response etc.

Text Books:
1. Principles of lasers, Fourth edition-by Orazio Svelto
3. Solid state laser engineering, first and second edition,
5. Principles of Laser and their applications, Callen, O’shea, Rhodes
6. Laser parameters, Heard Reference Books:
8. Gas lasers, Garret.

PHY Z09: LASER-II

2. Pulse transmission mode Q-switching, Mode locking-active and passive techniques Passive mode locking using dye cell, Distributed Feedback Lasers (and its importance for short pulse generation)

Text Books:
5. Application of lasers, John F. Ready.

**PHY Z10: THERMAL PHYSICS-I**

1. **Heat Conduction Fundamentals**: The significance of heat conduction; Heat flux; Fourier’s law for heat conduction; Heat conduction equation in different orthogonal coordinate systems; Boundary conditions; dimensionless heat conduction parameters; Homogeneous and non-homogeneous heat conduction problems; Conduction heat transfer in solids, fluids and complex materials.

2. **Methods of solution of heat conduction problems**: The use of Green’s function in the solution of non-homogeneous, time dependent heat-conduction problems; Application of Laplace transform in the solution of time dependent heat-conduction problems; one dimensional composite medium; generalized orthogonal expansion technique for homogeneous heat conduction problems; Eigen values and Eigen functions.

3. **Approximate Analytical Methods**: The integral method—basic concepts and applications; The variational Principles: Basic concepts,
variational form of one dimensional steady state heat conduction equation; The Ritz method: steady state heat conduction problem for a solid cylinder; The Galerkin method: construction of \( \varphi_j \) functions, Boundary conditions, steady state heat conduction problem for a rectangular region with heat generation at a constant rate.

4. **Numerical methods for conduction heat transfer**: Finite difference approximation of derivatives through Taylor’s series; Finite difference representation of steady state heat and time dependent conduction problems; errors involved in numerical solutions; Accuracy of solutions: Optimum step size; Method of choosing optimum step size; Applications of Finite difference methods to time dependent heat conduction problems.

**Reference Books:**

2. Thermal conductivity of solids by J. E. Parrott and A. D. Stuckes; Pion Limited.
3. Introduction to ceramics by Kingery, Bowen and Uhlmann, John Wiley & Sons (Second edn.).

**PHY Z11: THERMAL PHYSICS-II**

1. **Structures and Thermal properties of Ceramics**: Atomic bonding in solids; Crystal structures; Oxide and Silicate structures; Structure of oxide glasses; Density and thermal expansion of crystals and glasses; Thermal conduction processes; Phonon conductivity of single phase crystalline ceramics; Phonon conductivity of single-phase glasses; Photon conductivity; conductivity of multiphase ceramics

2. **Thermal properties of Complex materials**: A preview of complex materials and their structures; thermal properties of complex materials
like polymer composites and metallic/non-metallic foams; Anisotropy effects; Morphology effects; Phase interaction effects; The local and global scale or size effects; Nano-scale size effects and multi-scale modeling; Scale effect in temporal domain; Other complexities and bi-modular behaviors; Structural effects, biometrics and meta-materials

3. **Thermal conduction in nano-fluids**: Fundamentals of nano-fluids; Effect of particle material, particle size and shape; Effect of base fluid and particle volume fraction; Theoretical considerations: Effect of temperature and Brownian motion of nano-particles; Liquid layering around nano-particles; Clustering of nano-particles; Ballistic phonon transport in nano-particles.

4. **Techniques for measurement of thermal properties**: Guarded hot plate method for low thermal conductivity materials, Basic design considerations; Point source, line source and parallel wire methods for the measurement of thermal conductivity of solids, fluids and porous materials. Transient plain heat source for low to high thermal conductivity materials. Errors involved in these methods and their comparative study.

**Reference Books:**

1. Introduction to ceramics by Kingery, Bowen and Uhlmann, John Wiley & Sons (Second edn.).
2. Heat transfer in cold climates by Virgil J. Lunardini, Van Nostrand Reinhold Company (VNR)
3. Thermal conductivity of solids by J. E. Parrott and A. D. Stuckes; Pion Limited.78