University of Rajasthan, Jaipur
M.Sc. Physics Syllabus
Semester Scheme 2017-19

Contents:
1. Eligibility
2. Scheme of Examination
3. Semester Structure
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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 URA PG 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. Part 'A' of theory paper shall contain 10 Short Answer Questions of 20 marks, based on knowledge, understanding and
applications of the topics/texts covered in the syllabus. Each question will carry one mark for correct answer.

(2) Part "B" of paper will consisting of Four questions with internal choice (except in cases where a different scheme is specifically specified in the syllabus) of 20 mark each. The limit of answer will be five pages.

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

4. 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 Course
SEM: Seminar
PRJ: Project Work
RP: Research Publication

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

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>Classical Mechanics</td>
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<td>PHY 711</td>
<td>(Six Experiments)</td>
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Departments will offer minimum three and maximum five theory elective courses for the semester based on options submitted by students and availability of faculty to teach the course.
Second Semester

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<tr>
<th>S. No.</th>
<th>Subject Code</th>
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Departments will offer minimum three and maximum five theory elective courses for the semester based on options submitted by students and availability of Faculty to teach the course.
### Third Semester

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Departments will offer minimum three and maximum five theory elective courses for the semester based on options submitted by students and availability of Faculty to teach the course.

Dy. Registrar  
(Academic)  
University of Rajasthan  
JAIPUR
### Fourth Semester

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<th>S. No.</th>
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**Theory Elective 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  
H. GN: GENERAL  
I. TP: Thermal Physics  
J. CP: Computational Physics  
K. RP: Reactor Physics  
L. HP: Health Physics  
M. LP: Laser Physics

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<th>Elective Course Code</th>
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</table>

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 701: CLASSICAL MECHANICS**


**Reference Books:**

1. Goldstein - Classical 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 Schroödinger 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 eigen state (Spherical Harmonics), composition of angular momenta, Clebsch-Gordon Coefficients, tensor operators and Wigner Expant 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.


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.


3. **Magnetostatics**: Introduction and definition, Biot and Savart Law, the differential equations of magnetostatics and Ampere's law. Vector potential and magnetic induction for a current loop. Magnetic fields of a localized current distribution, Magnetic moment, Force and torque on and energy of a localized current distribution in an external induction,
Macroscopic equations, Boundary conditions on B and H Methods of solving Boundary value Problems in magnetostatics, Uniformly magnetized sphere, magnetized sphere in an external fields, permanent magnets, magnetic shielding, spherical shell of permeable material in an uniform field.

4. **Time varying fields, Maxwell's equations conservation laws:** Energy in a magnetic field, vector and scalar potentials, Gauge transformations, Lorentz gauge, coulomb gauge, Green function for the wave equation, Derivation of the equations of Macroscopic Electromagnetism, Poynting's Theorem and conservation of energy and momentum for a system of charged particles and EM fields. Conservation laws for macroscopic media. Electromagnetic field tensor, transformation of four potentials and four currents, tensor dissipation of Maxwell's equations.

**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 802: 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 804: CLASSICAL ELECTRODYNAMICS –II**

*(Same as H03)*

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 Electrodynamic 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 805: MATHEMATICAL METHOD IN PHYSICS
(Same as 703)

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. Lorentz covariance of Maxwell equation, Klein Gordon and Dirac Equation, Test of covariance of Schrödinger equation.

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 $C_4V$. Translation group and the reciprocal lattice.


**Reference books:**

2. *Applied Mathematics for Engineers and Physicists*; I. A. Pipe (McGraw Hill)
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 901: 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.


2. **Relativistic Formulation and 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.


Reference Books:

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

PHY 902: 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.


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. Huang: Statistical Mechanics
2. Reif: Fundamentals of Statistical and Thermodynamical Physics.

PHY 903: 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 ahard 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


**PHY X01: 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.

4. **Applications of S-matrix formalism**: The Coulomb scattering, Bhabha scattering, Moller scattering, and Compton scattering.

**Reference Books:**

1. Quantum Field Theory by F. Mandal & G. Shaw (Honh-Wiley).
3. Advanced Quantum Mechanics by J.J. Sakurai.
PHY X02: SOLID STATE PHYSICS

1. **Lattice Dynamics and Optical Properties of Solids:** Interatomic forces and lattice dynamics and simple metals, ionic and covalent crystals. Optical phonons and dielectric constants. Inelastic neutron scattering, Mossbauer effect, Debye-Waller factor, Anharmonicity, thermal expansion and thermal conductivity. Interaction of electrons and phonons with photons. Direct and indirect transitions Absorption in insulators, Polaritons, one-phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

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, excitations, 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. Giaver and AC and DC Josephson tunnelings.
(b) Cooper pairs and derivation of BCS Hamiltonian, results of BCS Theory (no derivation).

**Reference Books:**


**PHY X03: 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 formatin and breakup; Resonance scattering and reaction-Breit-Wigner dispersion formula for s-waves \( (l = 0) \), 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:


[Signature]

PHY 711 / PHY 811 General Physics Lab Experiments

1. Study following wave shaping circuits using discrete components
   a) High pass and Low pass filters
   b) Clipping circuits
   c) Clamping circuit

2. Study various flip-flop circuits and design counters to the base 16 up and down counter and an up counter to the base 10/9/7 using flip-flops.

3. Design and study single stage RC coupled transistor amplifier with lower half power frequency 500 HZ and gain 20.

4. Study following quantities in relation to thermal bias stability of a given transistor amplifier circuits
   a) Variation of Ic0 with temperature
   b) Variation of Ic with temperature
   c) Variation of S with temperature
   d) Distortion of ac signal with temp.

5. Design and study any two of the following circuits using IC 555 timer.
   a). Mono stable oscillator (pulse width W as 0.25 ms)
   b). A stable oscillator (freq. 300 HZ and duty cycle 75%)
   c). Ramp generator (slope = 10V/ms)
d). Voltage controlled oscillator.

6. Design and study RC phase shift oscillator of freq. 1.5 KHZ using op-amp 741

7. Design and study Wein bridge oscillator freq. 2 KHZ using op-amp 741

8. Study analogue to digital/digital to analogue conversion.

9. Design and study a stable multivibrator of freq. 3 KHZ & 1 KHZ both in symmetric and asymmetric mode

10. Study following application of op-amp 741
    i) Unit gain buffer
    ii) Adder
    iii) Subtractor
    iv) Integrator
    v) Differentiator
    vi) Comparator

11. Study following characteristics of op-amp 741
    i) Inverting mode operation
    ii) Non converting mode operation
    iii) Input impedance
    iv) output impedance
    iv) input offset current

12. To study the coupled oscillator, frequency response with mass variation.
    i) Amplitude response with frequency
    ii) Phase lag between driven and driver.

PHY 911 / PHY XII Advance Physics Laboratory Work

PART- A Nuclear Physics

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 (Tp) detector.
   (b) To determine attenuation coefficient (u) for rays from a given sources.
7. To study Compton scattering of gamma rays and verify the energy shift formula.

PART- B: Solid State Physics

1. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using four probe method.
2. To study Hall Effect and to determine hall coefficient.
3. To study the variation of rigidity of a given specimen as a function of the temperature.
4. To study the dynamics of a lattice using electrical analog.
5. To study L.SR and determine g-factor for a given spectrum.
6. To determine ultrasonic velocity and to obtain compressibility for a given liquid.
7. Study the characteristics of a given Klystron and calculate the mode number, I., I.S. and transit time.
8. Study the simulated L.C.R. Transmission line (audio frequency) and to find out the value for a Z0 experimentally from the graph.
9. Study the radiation pattern of a given Pyramidal horn by plotting it on a Polar graph paper. Find the half power beam width and calculate its gain.
10. Find the dielectric constant of a given solid (Teflon) for three different lengths by using slotted section.
11. Find the dielectric constant of a given liquid (organic) using slotted
12. Verification of Bragg's law using microwaves.

Theory Elective Courses
Cluster GN: GENERAL
PHY H01: 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
arithmetic. 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 H02: 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 H 04: NUMERICAL METHODS
(Same as 803)


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

**Reference books**:


Cluster AC: Astrophysics and Cosmology

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,


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

D. Registrar
University of Rajasthan
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. Schwarzchild 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.
Cluster CMP: Condensed Matter Physics

PHY B01: Condensed Matter Physics-I

1. **Phase transformation and alloys:** Equilibrium transformation of first and second order, equilibrium diagrams, phase rule, interpretation of phase diagrams, substitutional solid solutions, Vegard’s law, intermediate phases, Hume-Rothery rules, interstitial phases (carbides, nitrides, hydrides, borides). Martensitic transitions.

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 preparation of nanomaterials. Sol-gel and chemical co-precipitation method, effect of temperature on the size of the particles. Bottom up: cluster beam evaporation, ion beam deposition, top down: ball milling, DC and RF sputtering.

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, PIImperial College Press, 2004
11. Handbook of Nanostructured materials and nanotechnology

Cluster HEP: High Energy Physics

PHY C01: High Energy Physics I

2. Bound states. Discoveries and observations in experimental particle physics and relation to theoretical developments. Symmetries, group theory. The group SU(3), Finite Symmetry Group P and C, SU(2) of Isospin, The group SU(3)
4. Decay rates. Cross sections. Feynman diagrams. Introduction to Feynman integrals. The Dirac equation. Feynman rules for quantum electrodynamics (no derivation). Moller scattering, trace theorems and properties of gamma matrices, helicity representation at high energies. the electron propagator, the photon propagator
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 qwuark 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*
6. Donald Perkin, *Introduction to high energy physics*).
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 C06: 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.

Cluster EC: Electronics and Communication

PHY - D01: Electronics and Communication I

1. 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.

2. 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

3. 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 Gyatron
   Antenna parameters, Huygen source, Electromagnetic horn antenna. Introduction to microstrip patch antennas and array antennas

4. 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

1. Power Electronics:

2. 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.

3. Communication Electronics:
   Introduction to signals: Size, classification, signal operations, unit signal functions, ortogonality, correlation, trignometric 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.

4. Modulation and demodulation:
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).

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.

1. 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:

Cluster ES: Energy Studies

PHY E01: ENERGY STUDIES –I


2. Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open 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.


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**


**PHY E02: ENERGY STUDIES -II**


References:


Cluster PP: Plasma Physics

PHY F01: PLASMA PHYSICS-I


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 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


plasma waves, Landau damping, A Physical derivation of Landau damping, Low frequency ion acoustic waves, Ion Landau damping.


**References:**


**Cluster NT: Nanotechnology**

**PHY G 01: Nanotechnology-I**

1. **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.

2. **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
3. Physical and Chemical Methods of Nanostructured Materials


4. 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

1. Nanoscale Properties - I

Magnetism: Magnetic Moment in clusters or Nanoparticles, Magnetic Order, coercivity, Magnetocrystalline Anisotropy, thermal activation and Superparamagnetic effects.

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

2. 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.

3. Characterization Methods

4. 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:
Cluster TP: Thermal Physics

PHY 101: 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 $q$, 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.

5. **Conduction heat transfer in anisotropic medium**: Heat flux for anisotropic solids; Heat conduction equation for anisotropic solids; Boundary conditions; Thermal resistivity coefficients; Transformation of axis and conductivity coefficients; Geometrical interpretation of conductivity coefficients; The symmetry of crystals; One dimensional steady state and time dependent heat conduction in anisotropic solids; Heat conduction in orthotropic medium.
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 102: 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-modal 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 nanoparticles; Liquid layering around nano-particles; Clustering of nano-particles; Ballistic phonon transport in nano-particles.
4. Thermal properties of Permafrost: Distribution of permafrost; origin and existence of permafrost; geophysical processes involved in energy transfer; geophysical conditions affecting permafrost; surface energy balance; thermal regime of permafrost; steady state and transient relations; ground temperatures; thermal conductivity, specific heat, thermal diffusivity of soils.
5. 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.

Cluster CP: Computational Physics

PHY J01: 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

PHY J02: 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
Cluster RP: Reactor Physics

PHY K01: 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. Lamarsh
3. Fundamentals of Nuclear Reactor Physics – Elmer E. Lewis

PHY K02 Reactor Physics – II


Reference:

2. Introduction to Nuclear Engineering – John R. Lamarsh
3. Fundamentals of Nuclear Reactor Physics – Elmer E. Lewis
Cluster HP: Health Physics

PHY-L01: 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, immersion 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:

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 Gmbhi &Co KGaA
3. AERB SAFETY GUIDE NO.AERB/SG/G-8

4. Atomic Energy (Radiation Protection) Rules, 2004


PHY-L02: Health Physics-II

1. Standards, Regulations and Safety

Regulaory bodies: ICRP, AERB, NRC, IAEA ,NEA and their comparision, 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 radaiton safety, Atomic Energy (Radiation Protection) Rules, 2004, Annual reprot of AERB.

2. Health Physics Instrumentation:

Radiation detectors, Gasfilled detectors: GM tube detector, ion chamber, proportional counter, BF3 detector, scintilation 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-halif 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 defination, its classification, measurable qualities in emergency, declaration, termination, radiation emergency reporting authorities, formats, handling procedures, interventionalevel, averted dose, emergency instruments, radiation safety in emergency, contamination, controll 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


ICRP reports.


Cluster LP: Laser Physics

PHY M01: 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.


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

[Signature]

By Registrar

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1. Principles of lasers, Fourth edition by Orazio Svelto
5. Principles of Laser and their applications, Callen, O’shea, Rhodes
6. Laser parameters, Heard Reference Books:
8. Gas lasers, Garret.

PHY M02: 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 shorpt pulse generation)

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

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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.

Laboratory Elective Courses

PHY Y11/PHY Y22: Spectroscopy Lab

1. To determine the Rydberg constant using Hydrogen discharge tube and spectrometer.
2. To determine optical band gap of cds thin films using ocean optical spectrometer.
3. To verify the validity of Hartmann's formula using constant deviation prism for unknown material.
4. To determine the magnetostriction of unknown material using Michaelson interferometer.
5. To determine the dissociation energy of iodine using the concave grating on Ronald's mounting.
6. To study the diffraction pattern of LASER light using
   i. single slit
   ii. multi-slit
7. To study the Zeman splitting of Neon light using constant deviation prism and CCD camera.
8. To study the Raman spectra of C-H bands using Raman spectrometer.
9. Fabry parot interferometer.
10. Study of Elliptically polarised light by Babinet Compensartor.
11. Verification of Cauchey's Dispersion relation.

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**PHY Y12/Y22: Computational Physics Programming in C**

Write program in C Programming Languages based on course of PHY 105 and PHY H02 involving computations relevant to Physics.

**PHY Y13: Computational Astrophysics and Cosmology**

Computational work based on curriculum of elective papers of Cluster AP: Astrophysics and Cosmology.

**PHY Y14: Condensed Matter Physics Laboratory**

Laboratory work based on curriculum of elective papers of Cluster CMP: Condensed Matter Physics.

**PHY Y15: Computational High Energy Physics**

Computational work based on curriculum of elective papers of Cluster HEP: High Energy Physics.

**PHY Y16: Microwave Electronics Laboratory Work**

Laboratory work based on curriculum of elective papers of Cluster EC: Electronics and Communication.

**PHY Y17: Energy Studies Laboratory Work**

Laboratory work based on curriculum of elective papers of Cluster ES: Energy Studies.