UNIVERSITY OF RAJASTHAN, JAIPUR

M.A./M.SC./M.COM

(Physics)

2013-2014 (PREVIOUS)-I/II SEMESTER

2014-2015 (FINAL)- III/IV SEMESTER

Prepared by

16/9

Physics – 2013-2015

~~to 52.6%, (v) CGPA of 2.17 is equivalent to 41.04%, and (vi) CGPA of 1.11 is equivalent to 29.88%~~

2. **Eligibility:**
A candidate who has secured more than 50% or CGPA of 3.0 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 or Medicine or Pharmaceutical Science shall be eligible for admission to First Semester of a Master of Science course.

Same as Notified on Website by Adm. Committee

3. **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 two 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 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 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

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy	P
1.	PHY 101	Classical Mechanics	CCC	**5**	4	1	0	3	0
2.	PHY 102	Quantum Mechanics	CCC	**5**	4	1	0	3	0
3.	PHY 103	Classical Electrodynamics-I	CCC	**5**	4	1	0	3	0
4.	PHY 104	Mathematical Methods in Physics	CCC	**5**	4	1	0	3	0
5.	PHY 105	Programming in C	CCC	**4**	4	0	0	3	0
7.	PHY 131	Seminar-1	SEM	**2**	0	0	3	0	1
8.	PHY 111	Electronics Lab/ General Lab/ Spectroscopy Lab (Eight Experiments)	CCC	**8**	0	0	12	0	6
9	PHY 112	Computational Physics Programming in C	CCC	**4**	0	0	6	0	4

Second Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy	P
1.	PHY 201	Electronics	CCC	**5**	4	1	0	3	0
2.	PHY 202	Atomic and Molecular Physics	CCC	**5**	4	1	0	3	0
3.	PHY 203	Classical Electrodynamics-II	CCC	**5**	4	1	0	3	0
4.	PHY 204	Numerical Methods	CCC	**5**	4	1	0	3	0
5.		Core Elective	ECC	**6**	4	2	0	3	0

6.	PHY 211	Electronics Lab/ General Lab/ Spectroscopy Lab (Eight Experiments)	CCC	8	0	0	12	0	6
7	PHY 212	Numerical Methods Implementations using C Lab	CCC	4	0	0	6	0	4
8	PHY 221	Summer Training Programme (Min. 4 weeks after II Semester EoSE)	PRJ	4	0	0	24	0	0

Third Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy	P
1.	PHY 301	Advance Quantum Mechanics	CCC	5	4	1	0	3	0
2.	PHY 302	Statistical and Solid State Physics	CCC	5	4	1	0	3	0
3.	PHY 303	Nuclear Physics -I	CCC	5	4	1	0	3	0
4.		Core Elective	ECC	6	4	2	0	3	0
5.		Core Elective	ECC	6	4	2	0	3	0
6.	PHY 306	Seminar -2	SEM	2	0	0	3	0	1
7.	PHY 311	Advance Physics Lab (Eight Experiments)	CCC	8	0	0	12	0	6
8.	PHY 312 Or PHY 321	Elective Laboratory Work/Project Work	ECC/ PRJ	4	0	0	9	0	6

Fourth Semester

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	P	Thy	P
1.	PHY 401	Introduction to Quantum Field Theory	CCC	5	4	1	0	3	0
2.	PHY 402	Solid State Physics	CCC	5	4	1	0	3	0
3.	PHY 403	Nuclear Physics -II	CCC	5	4	1	0	3	0
4.		Core Elective	ECC	6	4	2	0	3	0
5.		Core Elective	ECC	6	4	2	0	3	0
6.	PHY 411	Advance Physics Lab (Eight Experiments)	CCC	8	0	0	12	0	6
7.	PHY 412 Or PHY 421	Elective Laboratory Work/Project Work	ECC/ PRJ	4	0	0	9	0	6/1
8.	PHY 431	Research Publication In Journals	RPJ	2	0	0	3	0	1
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Fourth Semester (Alternative)

S. No.	Subject Code	Course Title	Course Category	Credit	Contact Hours Per week			EoSE Duration (Hrs.)	
					L	T	S	Thy	P
1.	PHY 401	Introduction to Quantum Field Theory	SSC	5	0	0	10	3	0
2.	PHY 402	Solid State Physics-2	SSC	5	0	0	10	3	0
3.	PHY 403	Nuclear Physics -2	SSC	5	0	0	10	3	0
4.		Core Elective	SSC	6	0	0	12	3	0

5.		Core Elective	SSC	**6**	0	0	12	3	0
6.	PHY 422	Project Work in Industry Or Institution or University (16 week)	PRJ	**12**	0	0	24	0	1
9	PHY 431	Research Publication In Journals	RPJ	**2**	0	0	3	0	1
				41					

<u>Elective Core Courses:</u>

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

Elective Course Code	Specialization	Paper Title	Prerequisite
PHY A01	AC	Astrophysics -I	
PHY A02	AC	Astrophysics -II	
PHY A03	AC	General Theory of Relativity	
PHY A04	AC	Cosmology	
PHY A05	AC	Quantum Gravity and Quantum Cosmology	PHY A04 OR PHY A03
PHY	AC	Precision Tests in Astrophysics and Cosmology	PHY A01 or PHY

A06			A02 or PHY A04
PHY B01	CMP	Condensed Matter Physics -I	
PHY B02	CMP	Condensed Matter Physics -II	
PHY C01	HEP	High Energy Physics -I	
PHY C02	HEP	High Energy Physics -II	
PHY C03	HEP	High Energy Physics -III	
PHY C04	HEP	Renormalization	PHY C02
PHY C05	HEP	Supersymmetry	PHY C02
PHY C06	HEP	Physics Beyond Standard Model	PHY C02
PHY D01	EC	Electronics and Communications -I	
PHY D02	EC	Electronics and Communications -II	
PHY DO3	EC	Microwave Electronics	
PHY D04	EC	Satellite Communication and Remote Sensing	
PHY E01	ES	Energy Studies -I	
PHY E02	ES	Energy Studies -II	
PHY F01	PP	Plasma Physics -I	
PHY F02	PP	Plasma Physics -II	
PHY Z01	ON	Laser and Laser Applications	
PHY Z02	ON	Reactor Physics -1	
PHY Z03	ON	Reactor Physics –II	
PHY Z04	ON	Health Physics -I	
PHY	ON	Health Physics -II	

Z05			
PHY Z06	ON	Computational Physics -I	
PHY Z07	ON	Computational Physics -II	
PHY Z08	ON	Laser -I	
PHY Z09	ON	Laser -II	
PHY Z10	ON	Thermal Physics-I	
PHY Z11	ON	Thermal Physics-II	

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

1. Constraints, holonomic and non-holonomic constraints, D'Alembert's Principle and Lagrange's Equation, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Extension of Hamilton's Principle for non-conservative and non-holonomic systems, Method of Lagrange's multipliers, Conservation theorems and Symmetry Properties, Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space.
2. Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical Equation from Hamilton's variational principle. The principle of least action.
3. Canonical transformation, integral invariant of poincare: Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouvilee's theorem, Hamilton-Jacobi equation and its application.
4. Action angle variable adiabatic invariance of action variable: The Kepler problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications. Orthogonal transformation, Euler's theorem, Eigenvalues of the inertia tensor, Euler equations, force free motion of a rigid body.

Reference Books:

(1) Goldstein - Classical Mechanics

(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 Ehernfest Theorem, the time evolution of wave function, the schroodinger 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 spaceand 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 Expart theorem, c 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:

1. Ashok Das and A.C. Melissions: Quantum Mechanics - A modern approach (Gordon and Breach Science Publishers).
2. P.A.M. Dirac, Quantum Mechanics.
3. E. Merzbecher: Quantum Mechanics, Second Edition (John Wiley and sons)
4. L.P. Landau and E.M. Lifshitz, Quantum Mechanics - Relativistic theory (Pergamon Press)
5. A. Ghatak and S. Lokanathan: Quantum Mechanics - Theory and Applications, Third Edition (Mac. Millan, India Ltd.

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 wit 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 media. Boundary value problems with dielectrics. Molar polarizability and electric susceptibility. Models for molecular polarizability, electrostatic energy in dielectric media.
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, coloumb gauge, Green function for the wave equation, Derivation of the equations of

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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 104: MATHEMATICAL METHOD IN PHYSICS

a. 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.

b. 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.

c. 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.

d. 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:

1. Mathematical Methods for Physicists: George Arfken (Academic Press)
2. Applied Mathematics for Engineers and Physicists: L. 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 105: Computer Programming

- 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.
- 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.

- **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,

- Arrays and strings, structures, array of structures, Unions of structures, operations on bits, usage of enumerated data types. Bit-fields, Pointers to Function, Function returning Pointers.

Recommended reference books:

1. Robert W. Sebesta: Concepts of Programming Language, Addison Wesley, Pearson Education Asia, 1999.
2. Deitel and Deitel: How to Program C, Addison Wesley, Pearson Education Asia, 1999.
3. Bryon Gottfried, Programming with C, McGraw Hill International.

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 Multiv~bratorof given frequency and study its wave shape.
7. To study the characteristics ofFET and use it 0 design an relaxation oscillator and measure its frequency.
8. Tostudy 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. Determine Plack constant using solar Cell.
12. To determine Plack constant and work function by a photo-cell.
13. To study regqlated power supply using (A) Zener diode only (b) Zener diode with a series transistor (c) Zener diode with a shunt transistor.
14. To verify Fresnel's formula;
15. To study the percentage regulation and variation of Ripple factor, withload for a full wave rectifier. .
16. To study analog to digital and digital to analog conversion.
17. Io study a driven mechanical oscillator.
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 to I.
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.
26. Determination of velocity of Ultrasonic waves.
27. Study of Eliptically polarised light by Babinet Compensator.
28. Veafication of Cauchey's Dispersion relation.
29. Study of DC gatecontrol 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

1. **Operational Amplifiers:** Differential amplifier - circuit configurations - dual input, balanced output differential amplifier, DC analysis, inverting and non-inverting inputs, CMRR-constant current bias level translator. Block diagram of typical OP-Amp analysis. Open loop configuration, inverting and non-inverting amplifiers, Op-Amp with negative feedback, voltage series feedback, effect of feed back on closed loop gain, input resistance, bandwidth and output offset voltage, voltage follower. Practical Op-Amp,

input offset voltage-input bias current-input offset current, total output offset voltage, CMRR frequency response. DC and AC amplifier. integrator and differentiator.

2. **Oscillators and wave shapping 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 arithmatics, 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 sqaure wave generator. Opto-electronic Devices: Photo diode, Phototransistor, Light emitting Diode and their applications

Text and Reference Books:

1. "Electronic Devices and Circuit Theory" by Robert Boylested and Louis Nashdsky, PHI, New Delhi - 110001, 1991.
2. "OP-AMP and Linear Integrated Circuits" by Ramakanth, A. Gayakwad, PHI, Second Edition 1991.
3. "Digital Principle and Applications" by A.P. Malvino and Donald P. Leach, Tata McGraw Hill Company, New Delhi, 1993.

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).
2. Indistinguishability and exchange symmetry, many particle wave functions and Pauli's exclusion principle, spectroscopic terms for atoms.The helium atom, Variational method and its use in calculation of ground state energy. Hydrogen

molecule, Heitler London method for hydrogen molecule. WKB method for one dimensional problem, application to bound states (Bohr Sommerfeld quantization) and the barrier penetration.

3. Spectroscopy (qualitative):General features of the spectra of one and two electron system – singlet, doublet and triplet characters of emission spectra, general features of alkali spectra. Rotation and vibration band spectrum of a molecule, P,Q and R branches. Raman spectra for rotational and vibrational transitions, comparison with infrared spectra – application to learning about molecular symmetry. General features of electronic spectra, Frank and Condon's principle.
4. Laser cooling and trapping of atoms:The scattering force, slowing an atomic beam, chirp cooling, optical molasses technique, Doppler cooling limit, magneto optical trap. Introduction to the dipole force, theory of the dipole force, optical lattice. Sisyphus cooling technique – description and its limit. Atomic fountain. Magnetic trap (only qualitative description) for confining low temperature atoms produced by Laser cooling, Bose-Einstein condensation in trapped atomic vapours, the scattering length, Bose-Einstein condensate, coherence of a Bose-Einstein Condensate, The Atom Laser.

Reference Books :

1. G. Banewell – Atomic and Molecular spectroscopy
2. Christopher J. Foot – Atomic Physics, Oxford Master series, 2005
3. G.K. Woodgate, Elementray Atomic Structure, Second Edition Clarendon Press, Oxford.
4. T.A. Littlefield - Atomic and Molecular Physics.
5. Eistaberg and Rasmic- Quantum Physics of Atoms. Molecules Solids and Nuclear Particles.
6. Ashok Das and A.C. Melfessions. Quantum Mechanics ; A Modem Approach (Gordon and Breach Science Publishers).
7. White - Atomic Spectra.
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 o dissipative medium, superposition of waves in one dimension, group velocity, casualty connection between D and E. Kramers-Kroning relation.
2. Magnetohydrodynamics and Plasma Physics : Introduction and definitions, MHD equations, Magnetic diffusion, viscosity and pressure, Pinch effect, instabilities in pinched plasma column, Magnetohydrodynamics waves, Plasma oscillations, short wave length limit of plasma oscillations and Debye shielding distance.
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
2. Classical Electricity and Magnetism : Panofsky and Philips.
3. Introduction to Electrodynamics : Griffiths.
4. Classical Theory of Field : Landan and Lifshitz.
5. Electrodynamics of Continuous Media : Landau and Lifshitz.

PHY 204: NUMERICAL METHODS

1. Errors in Numerical Analysis: Source of Errors, Round off error, Computer Arithmetic, Error Analysis, Condition and stability, Approximation, Functional and Error analysis, the method of Undetermined Coefficients. use of interpolation formula, Iterated interpolation, Inverse interpolation, Hermite interpolation and Spline interpolation, Solution of Linear equations : Direct and Iterative methods, Calculation of eigen values and eigen vectors for symmetric matrices.
2. Solution of Nonlinear equation : Bisection method, Newton's method, modified Newton's method, method of Iteration, Newton's method and method of iteration for a system of causation Newtons' method for the case of complex roots. Integration of a function. Trapezoiddal and Simpson's rules. Gaussian quadrature formula, Singular integrals, Double integration.
3. Integration of Ordinary differential equation : Predictor-corrector methods, Runga-Kutta method. Simultaneous and Higher order equations. Numerical Integration And Differentiation of Data, Least-Squares Approximations, Fast Fourier Transform.
4. Elementary probability theory, random variables, binomial, Poisson and normal distributions.

Reference :

1. A Ralston and P. Rabinowitz : A First Course in Numerical Analysis, McGraw Hill (1985).
2. S.S. Sastry : Introductory Methods of Numerical Analysis, Prentice-Hall of India (1979).

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 Multi-vibrator of given frequency and study its wave shape.
7. To study the characteristics of FET and use it 0 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. Determine Plack constant using solar Cell.
12. To determine Plack constant and work function by a photo-cell.
13. To study regqlated power supply using (A) Zener diode only (b) Zener diode with a series transistor (c) Zener diode with a shunt transistor.
14. To verify Fresnel's formula;
15. To study the percentage regulation and variation of Ripple factor, withload for a full wave rectifier. .
16. To study analog to digital and digital to analog conversion.
17. To study a driven mechanical oscillator.
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 to I.
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.
26. Determination of velocity of Ultrasonic waves.
27. Study of Eliptically polarised light by Babinet Compensator.
28. Veafication of Cauchey's Dispersion relation.
29. Study of DC gatecontrol 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 totall 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 Dirace 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, Rayleigh scattering. Thomson scattering and the Raman effect, Radiation damping and Resonance fluorescence.

Reference Books :

1. Ashok Das and A.C. Milissiones : Quantum mechanics - A Modern Approach (Garden and Breach Science Publishers).
2. Eugen Merzbacher : Quantum Mechanics, Second Edition (John Wiley and Sons).
3. Bjorken and Drell : Relativistic Quantum Mechanics (McGraw Hill).
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 hear 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.
3. Theory of Metals : Fermi-Dirac distribution function, density of states, temperature dependence of Fermi energy, specific heat, use of Fermi-Dirac statistics in the calculation of thermal conductivity and electrical conduction band, Drude theory of light, absorption in metals.
4. Band Theory : Block theorem, Kronig Penny model, effective mass of electrons, Winger-Seqtz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method.

Reference Books :

1. Huag : Statistical Mechanics
2. Reif : Fundamentals of Statistical and Thermodynamical Physics.
3. Rice : Statistical mechanics and Thermal Physics.
4. Kittle : Elementray statistical mechanics.
5. Kittle : Introduction to solid state physics.
6. Palteros : Solid State Physics.
7. Levy : Solid State 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