SCHEME AND SYLLABI FOR

M.Sc. PHYSICS

(TWO YEARS/FOUR SEMESTERS PROGRAMME)

(Under Choice Based Credit System)

<u>w. e. f. 2019-20</u>

(70:30)

DEPARTMENT OF PHYSICS

GURU JAMBHESHWAR UNIVERSITY OF SCIENCE & TECHNOLOGY

HISAR-125001, HARYANA

Vision and Mission of the Department of Physics

Vision:

To inspire the young students towards understanding and learning the fundamental concepts of Physics and their applications for the development of new technologies in the national interests.

Mission:

Physics is regarded as the most significant subject among all scientific and technical disciplines. The mission of Physics department at Guru Jambheshwar University of Science & Technology is to provide both the undergraduate and postgraduate students strong qualitative and quantitative knowledge along with developing a problem solving attitude that may open up a wide range of career choices. In addition, the mission also includes encouraging the research scholars to conduct cutting- edge research resulting in new discoveries and innovations that expands the horizons of science and technology.

This mission will be accomplished by providing students with rigorous and comprehensive knowledge as well as bringing exciting research perspectives to the student community of Physics Department at Guru Jambheshwar University of Science & Technology.

M.Sc. (Physics): **2 years programme**

The Department offers M.Sc. Physics programme which caters to the needs of application oriented world. The programme comprises of Condensed Matter Physics, Materials Science and Laser Physics that forms a major tool for studying ceramics, polymers, ferrites, glass, biomolecules, non-linear optical materials etc. Photonics and Optical Communication are also recurring themes of the present course. The course on computational physics enables the students for computer simulations in research. A course on `Radiation Physics' is being offered in consultation with Health Physics Division of BARC Mumbai and Radio Ecology Centre has been established in the University. Laboratories are equipped with the modern experimental set up. One semester project work is an essential component of curriculum for M.Sc. Physics students.

ACADEMIC CURRICULUM

Semester I (Credits = 24, Marks = 600)		Semester II (Credits = 24, Marks = 600)	
P-I	PHL 501: Advanced Mathematical Physics	P-V	PHL 506: Condensed Matter Physics -I
P-II	PHL 502: Classical Mechanics	P-VI	PHL 507: Atomic and Molecular Spectroscopy
P-III	PHL 503: Quantum Mechanics	P-VII	PHL 508: Statistical Physics
P-IV	PHL 504: Integrated Electronics	P-VIII	PHL 509: Physics of Lasers
Practical-I	PHP 505A: Physics Lab-I	Practical-III	PHP 510A: Physics Lab-III
Practical-II	PHP 505B: Physics Lab-II	Practical-IV	PHP 510B: Physics Lab-IV
Semester III (Credits = 28, Marks = 700)		**Semester IV (Credits = 24, Marks = 600)**	
P-IX	PHL 511: Advanced Quantum Mechanics	PE-I	PHL 516(i): Physics of Nano Materials
P-X	PHL 512: Electrodynamics	PE-II	PHL 516(iii)/PHL 516(v): Condensed Matter Physics –II/Radiation Physics
P-XI	PHL 513: Nuclear Physics	PE-III	PHL 517(ii): Fiber Optics and Optical Communication
P-XII	PHL 514: Computational Physics	PE-IV	PHL 517(iii): Non Liner Optics
Practical-V	PHP 515A: Physics Lab-V	Practical-VII	PHP 519A: Radiation Physics Lab/ PHP 519B: Material Science Lab/ PHP 519C: Fiber Optics & Non Liner Optics Lab
Practical-VI	PHP 515B: Computational Physics Lab	Project	PHP 520: Project Work
Open Elective	PHL 500: Physics for Everyday Life		

P: Papers; PE: Programme Elective; GPL-General Physics Lab

Credits and Maximum Marks:

1. Papers (P-I - P-XVI); Credits = 06 (04 Theory + 02 Practical/Project) each; Total marks 150 each
2. Open Electives (OE); Credits=04; Total marks = 100 each

SEMESTER-I

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHL 501	P-I	Advanced Mathematical Physics	4	4	70	30	100
PHL 502	P-II	Classical Mechanics	4	4	70	30	100
PHL 503	P-III	Quantum Mechanics	4	4	70	30	100
PHL 504	P-IV	Integrated Electronics	4	4	70	30	100
PHP 505A	Practical-I	Physics Lab-I	4	8	70	30	100
PHP 505B	Practical-II	Physics Lab-II	4	8	70	30	100
		Total	24	32			

NOTE:

The nomenclature and content of Paper Code PHL 501 and MPL 101 are same.
The nomenclature and content of Paper Code PHL 502 and MPL 102 are same.
The nomenclature and content of Paper Code PHL 503 and MPL 103 are same.
The nomenclature and content of Paper Code PHL 504 and MPL 104 are same.

SEMESTER-II

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHL 506	P-V	Condensed Matter Physics-I	4	4	70	30	100
PHL 507	P-VI	Atomic and Molecular Spectroscopy	4	4	70	30	100
PHL 508	P-VII	Statistical Physics	4	4	70	30	100
PHL 509	P-VIII	Physics of Lasers	4	4	70	30	100
PHP 510A	Practical-III	Physics Lab-III	4	8	70	30	100
PHP 510B	Practical-IV	Physics Lab-IV	4	8	70	30	100
		Total	24	32			

NOTE:

The nomenclature and content of Paper Code PHL 506 and MPL 201 are same.
The nomenclature and content of Paper Code PHL 508 and MPL 203 are same.
The nomenclature and content of Paper Code PHL 509 and MPL 204 are same.

SEMESTER-III©

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHL 511	P-IX	Advanced Quantum Mechanics	4	4	70	30	100
PHL 512	P-X	Electrodynamics	4	4	70	30	100
PHL 513	P-XI	Nuclear Physics	4	4	70	30	100
PHL 514	P-XII	Computational Physics	4	4	70	30	100
PHP 515A	Practical-V	Physics Lab-V	4	8	70	30	100
PHP 515B	Practical-VI	Computational Physics Lab	4	8	70	30	100
PHL 500*	Open Elective	Physics for Everyday Life**	4	4	70	30	100
		Total	28	36			

SEMESTER-IV©

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHL 516(i)***	PE-I	Physics of Nano Materials	4	4	70	30	100
PHL 516(iii)***/ PHL 516(v)***	PE-II	Condensed Matter Physics – II/ Radiation Physics	4	4	70	30	100
PHL 517(ii)***	PE-III	Fiber Optics and Optical Communication	4	4	70	30	100
PHP 517(iii)***	PE-IV	Non Liner Optics	4	4	70	30	100
PHP 519A/ PHP 519B/ PHP 519C	Practical-VII (Specialization Specific)	Radiation Physics Lab/ Materials Science Lab/ Fiber Optics & Non Liner Optics Lab	4	8	70	30	100
PHP 520****	Project	Project Work	4		70	30	100
		Total	24				

Important Notes:

1. The department may offer one of the papers (up to 4 credit) to be done through MOOC/SWAYAM courses in a year/semester. The student shall be graded as per the evaluation done by these online courses.
2. The question paper shall contain 20% numerical problems in the relevant papers.
3. A student may opt for the respective MOOC's courses at their own in place of PEs with a maximum of 8 credits during the programme.
4. A student will be required to opt for four programme elective/ special papers out of the following three groups of specializations. A student may opt for two papers in any two of these groups. These (Special/ Elective) papers will be offered in the beginning of the IV Semester depending upon the availability of staff in the field of specialization(s).

   Programme Elective/Special Papers (Group-I)
   PHL 516 (i) Physics of Nano Materials
   PHL 516 (ii) Experimental Techniques
   PHL 516 (iii) Condensed Matter Physics-II
   PHL 516 (iv) Electronic Devices and Smart Materials
   PHL516 (v) Radiation Physics
   Programme Elective/Special Papers (Group-II)
   PHL 517 (i) Optoelectronics
   PHL 517 (ii) Fiber Optics and Optical Communication
   PHL 517 (iii) Non Linear Optics
   PHL 517 (iv) Applied Optics
   Programme Elective/Special Papers (Group-III)
   PHL 518 (i) Computational Technique and Computer Simulation
   PHL 518 (ii) Medical Physics
   PHL 518 (iii) Theoretical Nuclear Physics
   PHL 518 (iv) Environmental Physics

5. Each unit has been uniformly distributed for about 15 hours and full papers is for about 60 hours.

* A work of 4 credit to be opted by the students as per elective course from other departments.

** **PHL-500 Elective Paper: Physics for everyday life** is to be offered to the students of other department.

*** From the session 2019-20 onwards the papers to be offered have been tentatively identified in the above table of Curriculum. Changes if any, will be conveyed to the concerned quarter as and when made.

**** The evaluation of project report & presentation will be done internally by a committee of 3-4 Teachersat the end of the semester and will be submitted with the sessional marks.

© The scheme and syllabi of M.Sc. III and IV semesters will be revised later.

PHL501: Advanced Mathematical Physics

Marks (Theory): 70 **Credits: 4 (60 lectures)**

Marks (Internal Assessment): 30 **Time: 3 Hrs**

Note: Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives: This course has been formulated to introduce students to some important topics of mathematical physics which are relevant to other papers of M. Sc. Physics course. It includes matrices, group theory, special functions, functions of a complex variable and calculus of residues and integral transforms.	**Course Outcome:** After completing this course, students would be able to deal with mathematics that appears in other papers such as Classical Mechanics, Quantum Mechanics, Nuclear Physics, Condensed Matter Physics, etc.

UNIT- I

Group theory and Tensors: Definition of a group and illustrative examples, Group-multiplication table, cyclic groups, subgroups and cosets, permutation groups, conjugate elements and class structure, isomorphy and homomorphy, class multiplication. Groups representation by matrices, reducible and irreducible representations, the great orthogonality theorem and its geometric interpretation, Schur's Lemmas (Only statements), character of a representation Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3).

Tensors in index notation, Kronecker and Levi Civita tensors, inner and outer products, contraction, symmetric and antisymmetric tensors, quotient law, Noncartesian tensors, metric tensors, covariant and contravariant tensors,Covariant differentiation. Applications.

UNITII

Special Functions: Solution of Bessel differential equation, Second solution of Bessel's equation using Wronskian, Generating function, Recurrence relations, Integral representation; Legendre Polynomials: Pn(x) as solution of Legendre differential equation, Second solution of Legendre's equation using Wronskian, Generating function, Recurrence relations and special properties, Rodrigues, formula, Orthogonality of Pn(x); associated Legendre polynomials; Parity and orthogonality; Hermite and Laguerre's Polynomials: generating function & recurrence relations only.

Unit III

Integral Equations and Green's Function: Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory. Green's functions in one dimension and three dimension.

Fourier Series: Fourier series, Dirichlet conditions. General properties. Convolution and correlation, Advantages and applications, Gibbs phenomenon.

UNIT- IV

Integrals Transforms: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms. 3D Fourier transforms with examples. Application of Fourier Transforms to differential equations: 1D Wave and Diffusion/Heat Flow Equations.

Laplace Transform (LT) and its Properties, LTs of Derivatives and Integrals , LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of LT to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Reference Books:

1. Group Theory for Physicists : A.W. Joshi (Wiley Eastern, New Delhi) 2011.
2. Group Theory and Quantum Mechanics by Michael Tinkham.
3. Mathematical Methods for Physicists (6th edition) by G.B. Arfken& H. J. Weber
4. Matrices and Tensors in Physics : A.W. Joshi (Wiley Eastern, New Delhi) 2005.
5. Mathematical Physics : P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
6. Introduction to Mathematical Physics : C. Harper (Prentice Hall of India, New Delhi) 2006.

PHL-502: CLASSICAL MECHANICS

Marks (Theory): 70 **Credits: 4 (60 lectures)**

Marks (Internal Assessment): 30 **Time: 3 Hrs**

Note: The question paper will consist of nine questions in all. Question no. 1 will contain seven short answer type questions without any internal choice covering the entire syllabus and shall be compulsory. The remaining eight questions will be set from the four units with two questions from each unit. Candidate is required to attempt five questions in all with one compulsory question and one question from each unit.

Course Objective: The objective of the course is to provide a basic knowledge of Kepler's laws of planetary motion, Hamiltonian dynamics and theory of small oscillations so that they can apply these methods to solve real world problems. The multi-disciplinary topic 'Chaos' will enable the students to learn the techniques to handle the problems from the field of non-linear dynamics.	**Course Outcomes**: After completion of this course, students will be able to understand the basics of Two Body problem, Hamiltonian Dynamics, Poisson Brackets relations and small oscillations. In addition to this student will be familiar with the basic of non-linear dynamics.

UNIT –I

Two-body central force problem and Hamiltonian Dynamics

Virial theorem, Differential equation for the orbit, stability of orbit under central force, conditions for closed orbits, The Kepler's laws of planetary motion and their deduction, Scattering in a central force field,Legendre transformations and the Hamilton equations of motion, Routh's procedure, The physical significance of the Hamiltonian, Derivation of Hamilton's equations from a variational principle, The principle of Least Action.

UNIT –II

Poisson and Lagrangianbracket

The equations of canonical transformation, Examples of canonical transformations, The integral invariants of Poincare, Poisson brackets, Special cases of Poisson brackets, Poisson theorem, Poisson bracket relations, Jacobi's identity and its derivation, Lagrange brackets and its properties, Relationship between Poisson and Lagrange brackets and its derivation, Infinitesimal contact transformation, Angular momenta and Poisson bracket Relations, Liouville's Theorem.

UNIT –III

H-J Theory and theory of small oscillations

Hamilton-Jacobi equation for Hamilton's principal function, Harmonic Oscillator problem, action and angle variables, problem of harmonic oscillator using action angle variable, Theory of small oscillations: Formulation of the problem, Eigenvalue equation and the principle axis transformation, frequencies of free vibrations and normal coordinates, free vibrations of a linear triatomic molecule,

UNIT –IV

Introductory non-linear dynamics

Classical Chaos: Linear and nonlinear systems, periodic motion, Perturbation and Kolmogorov- Arnod-moser theorem, dynamics in phase space; Phase Trajectories-Singular Points, Phase Trajectories of Linear Systems, Phase Trajectories of Nonlinear Systems, Attractors, Chaotic Trajectories and Liapunov exponents, Poincare Maps, Bifurcation.

Reference Books:

1. Classical Mechanics, 3rd ed.,2002 by H.Goldstein, C. Poole and J. Safko, Pearson Edition
2. Classical Mechanics of particles by Classical Mechanics by John R. Taylor 2005, University Science Books.
3. Chaos and Integrability in nonlinear dynamics: An introduction (1989) by Michael Tabor
4. Nonlinear dynamics: Integrability, Chaos and patterns (2003) by M. Lakshmanan and S. Rajasekar

PHL 503: Quantum Mechanics

Marks (Theory): 70 | **Credits: 4 (60 lectures)**

Marks (Internal Assessment): 30 | **Time: 3 Hrs**

Note: The question paper will consist of nine questions in all. Question no. 1 will contain seven short answer type questions without any internal choice covering the entire syllabus and shall be compulsory. The remaining eight questions will be set from the four units with two questions from each unit. Candidate is required to attempt five questions in all with one compulsory question and one question from each unit.

Course Objectives: The primary objective of this course is to develop familiarity with various approximation methods applied to atomic, nuclear and solid-state physics and to scattering, which include: Time-independent perturbation theory and variational method.	**Course Outcome:** The students will be aware of the formal structure of the subject and will get equipped with the techniques of angular momentum, perturbation theory and scattering theory so that they can use these in various branches of physics as per their requirement.

UNIT-I

Angular Momentum: The angular momentum operators and their representation in spherical polar coordinates, solution of Schrodinger equation for spherically symmetric potentials, spherical harmonics, Angular momentum matrices and Pauli spin matrices, Connection between spin and statistics, Addition of angular momentum, Calculation of Clebsch-Gordan coefficients, Coupling of orbital and spin angular momentum. Wigner-Eckart theorem and its applications. Symmetries, conservation laws, degeneracy

UNIT-II

Stationary State Approximate Methods: Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator, Application to excited states, Ground state of helium.

Time Dependent Perturbation: General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light. Adiabatic and sudden approximations.

UNIT-III

The WKB approximation: Classical limit, Approximate solutions, Asymptotic nature of solutions, Solution near a turning point, Special case of linear turning point, Connection at the turning point, Asymptotic connection formulae, Application to energy levels of a quantum well, tunneling through a potential barrier and alpha decay

Semiclassical theory of radiation: Transition probability for absorption and induced emission, Electric dipole and forbidden transitions, Selection rules.

UNIT-IV

Scattering Theory: Basic concept of scattering, scattering amplitude, differential and total scattering cross sections, scattering by spherically symmetric potentials, partial waves and phase shifts, scattering by a perfectly absorbing sphere and by square well potential, Born approximation and its validity. its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles.

Text and Reference Books:

1. Quantum Mechanics, NouredineZettili, Wiley
2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
3. Quantum Mechanics: E. Merzbacher (John Wiley, Singapore), 2004
4. Quantum Mechanics: M.P. Khanna, (HarAnand, New Delhi), 2006.
5. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan (Tata McGraw Hill, NewDelhi) 2nd edition, 2004
6. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
7. Quantum Physics: S. Gasiorowicz (Wiley, New York), 3rd ed. 2003.
8. Quantum Mechanics, A. Ghatak&Loknathan, Mackmilan India Ltd.

PHL 504: Integrated Electronics

Marks (Theory): 70 | **Credits: 4 (60 lectures)**

Marks (Internal Assessment): 30 | **Time: 3 Hrs**

Note: Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives: To introduce students to fundamentals of with FET, OPAMP and to provide in-depth theoretical base of various flip flops, A/D Converter, ROM and RAM.	**Course Outcomes:** After this course student will be familiar with FET, OPAMP and basic of digital electronics.

UNIT-I

The Junction Field Effect Transistor: Basic structure & Operation, pinch off voltage, single ended geometry of JFET, volt – ampere characteristic, Transfer Characteristics. FET parameters, Biasing of the FET and setting of Q point using load line. MOSFET: Enhancement MOSFET, Threshold Voltage, Depletion MOSFET, Biasing of MOSFET, comparison of p & n channel FETs, FET small signal model, JFET low frequency common source and common drain amplifiers, FET application as Voltage Variable Resistor (VVR), UJT

UNIT-II

Differential Amplifier: Circuit configuration, dual input balanced output different amplifier, D.C. & A.C. analysis, Inverting and Non-inverting inputs, CMRR, Differential Amplifier using constant current bias, current mirror, level translator.

Operational Amplifier: Block diagram, ideal electrical characteristics, equivalent circuit, transfer characteristics, Open loop OP-AMP configuration: Differential, inverting & non-inverting amplifier, OP-AMP with negative feedback (a) Voltage series feedback: Effect of feedback on closed loop voltage gain, input resistance, output resistance, band width, output offset voltage. Voltage follower;
(b) Voltage shunt feedback: Effect of feedback on closed loop voltage gain, input resistance, output resistance, band width, output offset voltage.

UNIT-III

OP-AMP Applications: DC and AC amplifier (with offset null circuitry and external offset voltage compensating networks), summing, scaling, averaging (Non-inverting, Inverting and differential configuration), Integrator, Differentiator, Electronic analog computation, comparator. Oscillators: principles, Types, frequency stability, Phase shift oscillator, Wein-bridge oscillator, Square wave, Triangular wave and pulse generator

UNIT-IV

Combinational logic design: Binary Adders, Subtractors, Digital Comparator,Parity generators, Decoders/ Demultiplexers, Data selector/Multiplixer-Encoder

Sequential logic circuits: Flip-Flops – RS, JK, D, T, clocked, preset and clear operation, RAC in JK Flip-flops, master-slave JK flip-flops, Shift registers, Synchronous and Asynchronous counters, A/D Converters, D/A converter

Semiconductor Memories and its applications: ROM, PROM and EPROM, RAM, SRAM and DRAM.

Reference Books:

1. Ramakanth A. Gayakwad: OP-Amps & Linear integrated Circuits, Second Edition, 1991

2. Integrated Electronics by Millman and Halkias (Tata McGraw Hill), 2010.

3. Digital Design : Priciples and Practices, John F. Wakerly, 4th Ed.

4. Digital Principles and Applications by Malvino and Leach (Tata McGraw Hill), 2010.

5. Semiconductor Devices: Physics and Technology by S.M. Sze (John Wiley), 2007.

6. Digital Computer Electronics : Albert P. Malvino, Jerald A Brown (TataMcGraw Hill) 3rd ed. 2004.

PHP-505A: PHYSICS LAB –I

Marks (External) : 70 **Credits : 4**

Marks (Internal Assessment) : 30 **Time : 6 Hrs**

1. Each student should perform at-least seven experiments.

2 The students are required to calculate the error involved in a particular experiment.

List of Experiments:

1. Study of OP-AMP (Inverting Amplifier, Non-Inverting Amplifier, Differential amplifier, Current Controlled voltage source, Voltage Controlled Current source, CMRR)
2. To study the frequency response of low-pass, high-pass and band-pass filters and Reject Filter using OPAMP.
3. Study of OP-AMP for mathematical operations (Adder, Subtractor, DifferentiatorIntegrator,Logarithm amplifier).
4. Study of OP-AMP as Wave Form Generator (Square and Triangular wave generator).
5. Study of OP-AMP as Oscillators.
6. Study of V-I characteristics of JFET and MOSFET.
7. Study of transistor as multiplexer and demultiplexer.
8. Study of integrator and differentiator using passive components.
9. Study of flip flops (R-S, J-K, D, T type).
10. To generate and find the frequency of saw-tooth waves using UJT.
11. To study analog to digital and digital to analog convertor.
12. To study Multi-vibrators: mono stable, astable (free-running).
13. Study of shift registers and its applications.
14. Study of counters.

PHP-505B: PHYSICS LAB –II

Marks (External) : 70 **Credits : 4**

Marks (Internal Assessment): 30 **Time : 6 Hrs**

1. Each student should perform at-least seven experiments.
2 The students are required to calculate the error involved in a particular experiment.

List of Experiments:

1. Hall Effect Experiment
   a) To determine the Hall voltage developed across the sample material.
   b) To calculate the Hall coefficient and the carrier concentration of the sample material.
2. Study of magneto- resistance.
3. Determination magnetic susceptibility with a Gouy Balance.
4. To determine the ionization potential of mercury.
5. To study ESR.
6. To Study the characteristics of Solar Cell.
7. To study the phenomenon of magnetic hysteresis and calculate the resistivity, coercivity and saturation magnetization of a material using a Hysteresis loop tracer.
8. To determine band-gap of a semiconductor material.

PHL-506: Condensed Matter Physics-I

Marks (Theory): 70 **Credits: 4(60 lectures)**

Marks (Internal Assessment) : 30 **Time : 3 Hrs**

Note: The question paper will consist of nine questions in all. Question no. 1 will contain seven short answer type questions without any internal choice covering the entire syllabus and shall be compulsory. The remaining eight questions will be set from the four units with two questions from each unit. Candidate is required to attempt five questions in all with one compulsory question and one question from each unit.

Course Objective: *The aim of the course is to familiarize the students with the concepts of lattice vibrations and free electron theory, Band theory, dielectric and ferroelectric properties of materials, and Superconductivity.*	After completion of this course, students will be able to understand the *concepts of lattice vibrations and free electron theory, Band theory, dielectric and ferroelectric properties of materials, and Superconductivity.*

UNIT – I

Lattice vibrations: Vibrations of crystals with monatomic basis- Dispersion relation, First Brillouin zone, Group velocity, Two atoms per primitive basis- acoustical and optical modes; Quantization of lattice vibration: Phonons, Phonon momentum, Inelastic scattering of neutrons by phonons, Phonon heat capacity, Planck distribution, Density of states in 1D and 3D, Dulong and Petit's law, Debye and Einstein theories of Density of states, Debye T^3 law. Anharmonic crystal interaction, Thermal expansion and conductivity, Resistivity of phonon gas, Umklapp processes.

UNIT – II

Free electron theory of metals: Free electron gas models: energy levels and density of orbitals in 1D and 3D, Fermi Dirac distribution, Heat capacity of the electron gas, Experimental heat capacity of metals, Thermal effective mass, Electrical conductivity and Ohm's law, Matthiessen's rule, Umklapp scattering, Motion in magnetic fields and Hall effect, Wiedemann-Franz's law, Measurement of conductivity (Four probe method), Magneto-resistance.

Energy Band theory: Nearly free electron model, Origin of energy gap, Bloch functions, Kronig Penny model, wave equation of electron in a periodic potential, Number of orbitals in a band, Velocity and Effective mass of electron, Distinction between metals, semiconductors and insulators.

UNIT – III

Dielectric Properties of materials: Polarization, Local electric field at an atom, depolarization field, electric susceptibility, polarizability, Clausius-Mossotti relation, electronic polarizability, Normal and anomalous dispersion, Cauchy and Sellmeir relations, Langevin-Debye equation, Complex dielectric constant, optical phenomena

Ferroelectric Properties of materials: Structural phase transitions,ferroelectric crystals and its classification, soft optical phonons, Landau theory of phase transition, First and second order transitions, Anti-ferroelectricity, Curie-Weiss law, Ferroelectric domains, PE hysteresis, Piezoelectric effect, Pyroelectric effect, Electrostrictive effect

UNIT – IV

Superconductivity: Experimental Results, Critical Temperature, Critical magnetic field, Meissner effect, Type I and type II Superconductors, London's Equation and Penetration Depth, Thermodynamically and optical properties: energy gap, heat capacity and entropy, Isotope effect, BCS theory, BCS ground state, Flux quantization, persistent current, Josephson effect, Macroscopic quantum interference, High TC superconductors; Critical fields and critical currents, Hall number

Reference Books:

1) Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.

2) K.V. Keer, Principles of solid state physics, Wiley - Eastern, 1993.

3) Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.

4) Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

5) Introduction to Solid State Physics, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.

PHL507: Atomic and Molecular Spectroscopy

Marks (Theory): 70 **Credits: 4(60 lectures)**

Marks (Internal Assessment) : 30 **Time : 3 Hrs**

Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives

In this course, students will learn important concepts of atomic and molecular physics. IR, Raman and electronic band spectra of diatomic molecules will be studied. In addition to this NMR and ESR techniques will be introduced.

Course Outcome

The expected outcome is that student is familiar with different types of atomic and diatomic models and their spectra. Student will also be familiar with NMR and ESR techniques

UNIT- I

The diatomic molecule as the Vibrating Rotator: Energy levels, IR and Raman spectra; Comparison of observed spectra with the IR and Raman spectra based on vibrating-rotator model, Intensities in Rotational, Vibrational and vibrational-rotational spectra; Symmetry properties of the Rotational levels: Influence of nuclear spin. Isotope effect.

Electronic energy and Total energy: Resolution of the total Eigen function, Resolution of Total energy. Born Oppenheimer approximation,

UNIT- II

Vibrational structural of Electronic transitions: Progression and Sequences; Rotational structure of Electronic bands: Band-head formation, Fortrat parabola; Intensity distribution in the Vibrational structure: The Franck-Condon principle-Absorption and Emission (Condon parabola). Intensity distribution in the Rotational structure

UNIT- III

Classification of Electronic states: Orbital angular momentum, spin. Total angular momentum of electrons, multiplets, electronic energy of a multiplet term, alteration of multiplicities. Symmetry properties of electronic Eigen functions, coupling of rotational and electronic motion: Hund's coupling, uncoupling phenomena, Symmetry properties of the rotational levels

UNIT- IV

NMR: Basic principles, Classical and quantum mechanical description, Bloch equations, Spin-spin and spin-lattice relaxation times, chemical shift and coupling constant, Experimental methods, single coil and double coil methods, High resolution methods; ESR: Basic principle, ESR spectrometer, nuclear interaction and hyperfine structure, relaxation effects, g-factor, Characteristics, Free radical studies and biological applications.

Reference Books:

Atomic spectra & atomic structure by G. Hertzberg;
Introduction to Atomic spectra by H.E White;
Spectra of diatomic molecules by G. Herzberg.

PHL-508: Statistical Physics

Marks (Theory): 70 **Credits: 4(60 lectures)**

Marks (Internal Assessment) : 30 **Time : 3 Hrs**

Note: Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objective: The aim and objective of the course on Statistical Mechanics is to equip the M.Sc. (H.S.) student with the techniques of Ensemble theory so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.	**Course Outcomes:**On successful completion of the course, students should be able to: 1. discuss the various classical ensembles and quantum ensembles 2. solve the statistical mechanics problems using ensemble theory 3. explain the connection between classical statistical mechanics and quantum statistical mechanics 4. explain the concept of density matrix

UNIT- I

Statistical Basis of Thermodynamics: Contact between Statistics and Thermodynamics, The Classical ideal gas, Gibbs Paradox and its solution.

Ensemble Theory: The micro canonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations.

UNIT- II

Density matrix Formalism: Density Matrix, statistics of indistinguishable particles, Maxwell-Boltzmann , Fermi-Dirac and Bose-Einstein statistics,properties of ideal Bose-Einstein and Fermi-Dirac gases, Degenerate Free electron gas, Pauli paramagnetism Bose-Einstein condensation, Einstein model of lattice vibration, Debye theory of specific heat laser cooling of atom as an example of Bose Condensate, Planck's radiation formula(Black body Radiation)

UNIT- III

Quantum Statistics of Ideal Systems: Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behavior of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free-electron gas at low temperatures, Pauli paramagnetism.

UNIT- IV

Elements of Phase Transitions and Fluctuations: First- and second-order phase transitions, diamagnetism, paramagnetism, and ferromagnetism, a dynamical model of phase transitions, Ising and Heisenberg models, Thermodynamic fluctuations, random walk and Brownian motion, introduction to nonequilibrium processes, diffusion equation.

Reference Books:

F. Reif	Statistical and Thermal
K.Huang	Statistical Mechanics
R.K.P atharia	Statistical Mechanics
ESR Gopal	Statistical Mechanics

PHL-509: Physics of Lasers

Marks (Theory): 70 **Credits: 4(60 lectures)**

Marks (Internal Assessment) : 30 **Time : 3 Hrs**

Note: Paper setter is to set nine questions in all. Question no. 1 (compulsory based on the entire syllabus) will consist of seven short answer type questions, each of two marks. Rest of Eight questions is to be set uniformly selecting two questions from each Unit. A student is required to attempt five questions in all selecting one from each Unit and a compulsory question.

Course Objectives	**Course Outcomes**
The main aims of this course are to develop a working knowledge and conceptual understanding of important topics in contemporary laser physics at a quantitative level. A key objective is to enable the student to undertake quantitative problem-solving relating to the design, performance and applications of lasers	Students who complete the course will learn about the physics of lasers and their applications. This course develops a conceptual understanding of the classical approach to laser physics, and a perspective of areas of applicability.

Unit-I

The Einstein Coefficients, Absorption and Emission cross-sections; Light amplification by an atomic system; Threshold condition; Origin of Line Shape function: Lorentzian and Gaussian shape functions; Line Broadening mechanisms - Homogeneous broadening: Natural Broadening, Collision broadening; Inhomogeneous broadening: Doppler Broadening.

Unit-II

Laser Rate Equations: Two Level laser system, Three Level laser system, Four Level Laser Systems (Threshold Population, threshold pump rate, Laser power output with suitable examples), Variation of laser power around threshold; Optimum output coupling.

Cavity modes: Number of modes in 1D, 2D and 3D cavities, Resonance: Sharpness of resonance, Q and finness, photon life time.

Unit-III

Laser oscillations and amplification in Homogeneous broadened transition;Laser oscillations and amplification in Inhomogeneous broadened transitions; Saturation behaviour of homogeneously and inhomogeneously broadened transitions; Multimode oscillations; Spatial and Spectral hole burning - Lamb Dip;

Gaussian Beams and its properties, Beam waist, Rayleigh parameter; Physical description of lowest order TEM_{00} mode: Amplitude factor, Longitudinal and Radial Phase factors.

Unit-IV

Optical Resonators: Optimization of favourable losses, Resonance frequency; Active and Passive Resonators; Open Resonators; Q-factor of Resonator; Losses in Resonators: Diffraction losses; Main Parameter of Resonators (with two mirrors); Stability Criteria.
Pumping Processes: Optical Pumping; Conversion efficiency, Electrical pumping; Excitation by Resonance energy transfer; Physical description, Energy Levels, Excitation mechanism and Applications of Nd:YAG laser, CO_2 laser, Dye laser.

Text and Reference Books:

Laser Electronics, J.T.Verdeyen, Prentice Hall (1995)
Lasers & Electro-Optics: Fundamental & Engineering C.C.Davis, Cambridge (1996)
Lasers Fundamentals, W.T. Silfvast, Cambridge (1996)
Principles of Lasers, O.Svelto, Plenum (1989)
Laser Physics, L.V.Tarasov, Mir (1983)
Quantum Electronics, A.Yavir, John Wiley (1992)
Laser: Theory & Applications, A. Ghatak& K. Tayagrajan, Macmillan India
Introduction to Laser Physics, K. Shimoda, Springer (1986)
Lasers & non-Linear Optics, B.B.Laud

PHP-510A: PHYSICS LAB –III

Marks (External) : 70 **Credits : 4**

Marks (Internal Assessment): 30 **Time : 6 Hrs**

1. ***Each student should perform at-least seven experiments.***

2 The students are required to calculate the error involved in a particular experiment.

List of Experiments:

1. To determine wavelength and angular divergence of LASER beam.
2. Demonstration of Temporal coherence and measurement of wavelength of laser light using Michelson interferometer.
3. Measurement of refractive index using Brewester angle.
4. Febry-Parrot interferometer.
5. Study of spectrum of iodine vapour and deduce force constant for the iodine molecule.
6. To study modulation and demodulation (Amplitude and frequency).
7. To study and perform Pulse Amplitude Modulation and Demodulation.
8. To study and perform Pulse Width Modulation and Demodulation.
9. To study and perform Pulse Position Modulation and Demodulation.

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PHP-510B: PHYSICS LAB –IV

Marks (External) : 70 **Credits : 4**

Marks (Internal Assessment): 30 **Time : 6 Hrs**

1. Each student should perform at-least seven experiments.
2 The students are required to calculate the error involved in a particular experiment.

List of Experiments:

1. Study of P-E hysteresis loop for ferroelectric ceramic.
2. Determination of Rydberg constant.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. Thermo-luminescence studies.
5. High temperature superconductivity experiment.
6. Study of Zeeman Effect.
7. Linear and mass attenuation coefficients for the 662 keV gamma for Al, Cu and Pb materials
8. Linear and mass attenuation coefficients for the beta particles of Sr^{90} source for Al, Cu and Pb materials
9. Study of Energy Resolution of scintillation Detector as a function of $E\gamma$
10. Measurement of alpha spectra of alpha radioactive sample using a semiconductor detector and vacuum chamber
11. Study of detection efficiency of scintillation Detector as a function of $E\gamma$ using different sources.