SCHEME AND SYLLABI FOR

M.Sc. PHYSICS

(TWO YEARS / FOUR SEMESTERS PROGRAMME)

(Under Choice Based Credit System)

1st to 4th semester w. e. f. 2019-20 batch onward

(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. Optional one semester project work is included in the curriculum for M.Sc. Physics students.

Scheme of M.Sc. Physics (2 Years) Programme under Choice Based Credit System (w.e.f. 2019-20)

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
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 = 24, Marks = 600)		**Semester IV (Credits = 20, Marks = 500)**	
P-IX	PHL 511: Nuclear Physics	P-XII	PHL 516: Advanced Quantum Mechanics
P-X	PHL 512: Electrodynamics	PE-II	PHL 517: Group II (A/B/C/D)
P-XI	PHL 513: Computational Physics	PE-III*	PHL 518: Physics of Nano Materials / Spectroscopy/Radiation Physics
PE-I	PHL 514: Group I (A/B/C/D)	Practical -VI	PHP 519A: Physics Lab-VI (Specialization Specific Lab)
Practical-V	PHP 515: Physics Lab-V (Computational Physics Lab)	Practical-VII	PHP 519B: Physics Lab-VII (Specialization Specific Lab)
Open Elective	PHL500: Physics for Everyday Life	**OR**	
		Project	PHP-520: Project (Major)

P: Papers; PE: Programme Elective;

Credits and Maximum Marks:

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

Scheme of M.Sc. Physics (2 Years) Programme under Choice Based Credit System (w.e.f. 2019-20)

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	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 507 and MPL 202 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	Nuclear Physics	4	4	70	30	100
PHL 512	P-X	Electrodynamics	4	4	70	30	100
PHL 513	P-XI	Computational Physics	4	4	70	30	100
PHL 514	PE-I	Group I (A/B/C/D)	4	4	70	30	100
PHP 515	Practical-V	Physics Lab-V (Computational Physics Lab)	4	8	70	30	100
PHL 500***	Open Elective**	Physics for Everyday Life***	4	4	70	30	100
		Total	24	28			

The nomenclature and content of Paper Code PHL 511 and MPL 301 are same.
The nomenclature and content of Paper Code PHL 512 and MPL 302 are same.
The nomenclature and content of Paper Code PHL 513 and MPL 303 are same.
The nomenclature and content of Paper Code PHL 514(i) and MPL 304(i) / PHL 514(ii) and MPL 304(ii) / PHL 514(iii) and MPL 304(iii) / PHL 514(iv) and MPL 304(iv) are same.

SEMESTER-IV

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHL 516	P-XII	Advanced Quantum Mechanics	4	4	70	30	100
PHL 517	PE-II	Group-II (A/B/C/D)	4	4	70	30	100
PHL 518	PE-III*	Physics of Nano material / Spectroscopy/Radiation Physics	4	4	70	30	100
PHP- 519A	Practical-VI	Physics Lab-VI (Specialization Specific Lab)	4	4	70	30	100
PHP- 519B	Practical-VII	Physics Lab-VII (Specialization Specific Lab)	4	4	70	30	100
		Total	20				

The nomenclature and content of Paper Code PHL 516 and MPL 401 are same.
The nomenclature and content of Paper Code PHL 517(i) and MPL 402(i)/ PHL 517(ii) and MPL 402(ii) / PHL 517(iii) and MPL 402(iii) / PHL 517(iv) and MPL 402(iv) are same.
The nomenclature and content of Paper Code PHL 518 and MPL 403 are same.

OR

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHP-520	Project#	Project (Major)	20		350	150	500

Important Notes:

1. The question paper shall contain 20% numerical problems in the relevant papers.
2. 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.
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. The 4 credits assigned to Physics Lab shall include seminar and that will be a part of internal evaluation.
5. The student has to opt for PE-I and PE-II from respective groups (Table 1) keeping in view the related papers of his/her area of interest. The courses will be offered depending upon the strength of students (Minimum 10 students and maximum 50% of the strength of students in a particular class) for a particular course of option subject to availability of faculty. Student is required to opt same discipline /specialization from the two groups.

TABLE- 1

Option	Group –I	Group –II
A	PHL514(i) Materials Science-I	PHL517(i) Materials Science-II
B	PHL514(ii) Photonics- I (Fibre Optics and Communication)	PHL517(ii) Photonics – II (Nonlinear Optics)
C	PHL514(iii) Advanced Nuclear Physics-I (Nuclear Models)	PHL517(iii) Advanced Nuclear Physics-II (Nuclear Reactions)
D	PHL514(iv) Theoretical Condensed Matter Physics-I	PHL517(iv) Theoretical Condensed Matter Physics-II

***** The student will be offered one of the papers for PE-III (PHL-518) from Physics of Nano materials/Spectroscopy/Radiation Physics subject to availability of faculty.

** 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.

*The candidate shall be required to submit statement of purpose (SOP) if he/she wish to undertake major project (*PHP-520*) in final semester (Semester- IV) along with the consent from one of the regular faculty member of the department for supervision (The faculty can give consent to one student only). The SOP will be evaluated by four member's committee chaired by Chairperson along with supervisor as one of the member.*

- *The criteria for selection of students for major project (*PHP-520*) in final semester (Semester-IV) is as under:*

i) *The students must have passed all the lower semester exams (1st to 2nd semester).*

ii) *The students merit will be framed as follows:*
   a) *50% weightage from 1st & 2nd semester aggregates marks*
   b) *50% weightage of SOP evaluation*

iii) *maximum 10% of the total strength of students will be selected on merit basis for project.*

- *The guidelines for SOP will be provided by the department.*

- A student opting for major project (PHP-520) is required to undertake 16-20 weeks' (one semester) project in semester IV. He/she is supposed to submit acceptance-cum-recommendation letter from a Faculty from a National level institution /'A' grade University including GJUS&T by the end of IIIrd semester.

The evaluation of major project report & presentation out of 500 marks will be done as follows:

1. *150 marks by the concerned supervisor based on overall internal assessment.*
2. *200 marks through presentation of major project before four member's committee chaired by Chairperson (Each member to award out of 50 marks)*
3. *150 marks by inviting the external examiner in the relevant area. The external examiner may be asked to evaluate up to the maximum of 10 students in the relevant area.*

SEMESTER-I

PHL 501: Advanced Mathematical physics

Marks (Theory): 70 **CREDITS: 4 (60 Lectures)**
Marks (Internal Assessment): 30 **Time: 3 hours**

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 1. The question paper shall contain 20% numerical problems in the relevant papers

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 examples, Group-multiplication table, conjugate elements and class structure, Subgroups, Isomorphism and homomorphism, 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.

Unit II

Special Functions: Solution of Bessel differential equation, Second solution of Bessel's equation using Wronskian, Generating function, Recurrence relations, Integral representation, Application to single slit diffraction; Legendre Polynomials and its solution, Second solution of Legendre's equation using Wronskian, Generating function, Recurrence relations and special properties, Rodrigues formula, Orthogonality, Application to electric multipoles; Associated Legendre Functions; Parity and orthogonality; Hermite and Laguerre's functions. Hilbert-Schmidt theory. Green's functions in one dimension and three dimension.

Unit III

Complex Variables: Cauchy-Riemann conditions, analyticity, Cauchy-Goursat theorem, Cauchy's Integral formula, branch points and branch cuts, multivalued functions, Taylor and Laurent expansion, singularities and convergence, calculus of residues, evaluation of definite integrals, Dispersion relation, Optical dispersions, Causality.

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

Unit – IV

Integral 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 Transforms: 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, Forced 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: 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

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: 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

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, Nouredine Zettili, 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

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 eight experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary.

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 study ESR.
5. To study the phenomenon of magnetic hysteresis and calculate the resistivity, coercivity and saturation magnetization of a material using a Hysteresis loop tracer.
6. To determine material constant, band-gap and temperature variation of characteristics of a semiconductor material
7. Determination of e/m ratio by Helical Method
8. Study of Absorption coefficients
9. Thermo-luminance study
10. Dielectric constant of dielectric material with frequency.

PHP-505B: PHYSICS LAB –II

Marks (External) : 70	**Credits : 4**
Marks (Internal Assessment) : 30	**Time : 6 Hrs**

1. Each student should perform at-least eight experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary.

List of Experiments:

1. Study of OP AMP as Inverting, Non-inverting, Adder and Subtractor.
2. Study of OP AMP as Square wave generator, Differentiator and Integrator.
3. Study of OP AMP as Current Controlled Voltage Source (CCVS) and Voltage Controlled Current Source (VCCS).
4. To determine Common Mode Rejection Ratio (CMRR) in differential Amplifier.
5. To determine Open Loop Gain in differential Amplifier.
6. Study of OP AMP as RC Phase Shift Oscillator and to determine frequency of oscillation.
7. To study and Plot the V- I Characteristics of MOSFET.
   (a) Drain Characteristics
   (b) Transfer Characteristics
8. To study and plot the V- I characteristics of JFET and to evaluate following parameters:
   (a) DC Drain resistance
   (b) Transconductance
   (c) Amplification factor
9. To study and plot the V- I characteristics of UJT and to evaluate following parameters:
   (a) Intrinsic Stand- off Ratio.
   (b) Inter base resistance.
10. To study the frequency response of Active Low pass, High pass filter circuits.
11. To study the frequency response of Active Band Pass Filter and Narrow Reject T-Notch filter circuits.

SEMESTER-II

PHL-506: Condensed Matter 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

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.	**Course Outcomes:** 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.

PHL-507: Atomic and Molecular Spectroscopy

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: 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:

1) Atomic spectra & atomic structure by G. Hertzberg;
2) Introduction to Atomic spectra by H.E White;
3) 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

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.Patharia	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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: 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	**Course Outcomes:** 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; Cavity modes: Number of modes in 1D, 2D and 3D cavities; Threshold condition; Origin of Line Shape function: Lorentzian and Gaussian shape functions.

UNIT-II

Line Broadening mechanisms - Homogeneous broadening: Natural Broadening, Collision broadening; Inhomogeneous broadening: Doppler Broadening. 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;

UNIT-III

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.
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;
Physical description, Energy Levels, Excitation mechanism and applications of Nd:YAG laser, CO_2 laser and 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 eight experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary.

List of Experiments:

1. To Study the characteristics of Solar Cell.
2. Study of Franck-Hertz experiment.
3. Study of energy band gap and diffusion potential of P-N junction.
4. Study of Faraday effect
5. Study of Zeeman effect
6. Determination of dielectric constant and curie temperature of a material
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.

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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 eight experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary.

List of Experiments:

1. Analysis of operation of Counter Converter.
2. Testing the working of a Monolithic converter.
3. Study of R-S, J-K, D- and T- Type Flip Flop.
4. Study of IC555 as an astable and monostable multivibrator.
5. i) Functional verification and recording of transfer characteristics of weighted resistor D/A converter
   ii) Functional verification of D/A converter with Ladder network and recording of transfer characteristic of Ladder Network D/A converter.
   iii) Functional verification of an integrated D/A converter.
6. Determination and verification of input frequency by Wein Bridge using DPM.
7. Study of Wein Bridge Oscillator and visualize effect on output frequency with variation in RC combination.
8. Determination of power distribution within the laser beam.
9. To measure the laser beam spot size.
10. To measure the divergence of laser beam.
11. Distance measurement by triangularisation method using laser.

M.Sc. PHYSICS

(TWO YEARS / FOUR SEMESTERS PROGRAMME)

(Under Choice Based Credit System)

3rd to 4th semester w. e. f. 2019-20 batch onward

(70:30)

SEMESTER-III

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHL 511	P-IX	Nuclear Physics	4	4	70	30	100
PHL 512	P-X	Electrodynamics	4	4	70	30	100
PHL 513	P-XI	Computational Physics	4	4	70	30	100
PHL 514	PE-I	Group I (A/B/C/D)	4	4	70	30	100
PHP 515	Practical-V	Physics Lab-V (Computational Physics Lab)	4	8	70	30	100
PHL 500***	Open Elective**	Physics for Everyday Life***	4	4	70	30	100
		Total	24	28			

The nomenclature and content of Paper Code PHL 511 and MPL 301 are same.
The nomenclature and content of Paper Code PHL 512 and MPL 302 are same.
The nomenclature and content of Paper Code PHL 513 and MPL 303 are same.
The nomenclature and content of Paper Code PHL 514(i) and MPL 304(i) / PHL 514(ii) and MPL 304(ii) / PHL 514(iii) and MPL 304(iii) / PHL 514(iv) and MPL 304(iv) are same.

SEMESTER-IV

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHL 516	P-XII	Advanced Quantum Mechanics	4	4	70	30	100
PHL 517	PE-II	Group-II (A/B/C/D)	4	4	70	30	100
PHL 518	PE-III*	Physics of Nano material / Spectroscopy/Radiation Physics	4	4	70	30	100
PHP- 519A	Practical-VI	Physics Lab-VI (Specialization Specific Lab)	4	4	70	30	100
PHP- 519B	Practical-VII	Physics Lab-VII (Specialization Specific Lab)	4	4	70	30	100
		Total	20				

The nomenclature and content of Paper Code PHL 516 and MPL 401 are same.
The nomenclature and content of Paper Code PHL 517(i) and MPL 402(i)/ PHL 517(ii) and MPL 402(ii) / PHL 517(iii) and MPL 402(iii) / PHL 517(iv) and MPL 402(iv) are same.
The nomenclature and content of Paper Code PHL 518 and MPL 403 are same.

OR

Paper Code	Course opted	Nomenclature	Credits	Hr/ week	Marks		
					Ext.	Int.	Total
PHP-520	Project#	Project (Major)	20		350	150	500

Important Notes:

1. The question paper shall contain 20% numerical problems in the relevant papers.
2. 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
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. The 4 credits assigned to Physics Lab shall include seminar and that will be a part of internal evaluation.
5. The student has to opt for PE-I and PE-II from respective groups (Table 1) keeping in view the related papers of his/her area of interest. The courses will be offered depending upon the strength of students (Minimum 10 students and maximum 50% of the strength of students in a particular class) for a particular course of option subject to availability of faculty. Student is required to opt same discipline /specialization from the two groups.

TABLE- 1

Option	Group –I	Group –II
A	PHL514(i) Materials Science-I	PHL517(i) Materials Science-II
B	PHL514(ii) Photonics- I (Fibre Optics and Communication)	PHL517(ii) Photonics – II (Nonlinear Optics)
C	PHL514(iii) Advanced Nuclear Physics-I (Nuclear Models)	PHL517(iii) Advanced Nuclear Physics-II (Nuclear Reactions)
D	PHL514(iv) Theoretical Condensed Matter Physics-I	PHL517(iv) Theoretical Condensed Matter Physics-II

***** The student will be offered one of the papers for PE-III (PHL-518) from Physics of Nano materials/Spectroscopy/Radiation Physics subject to availability of faculty.

** 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.

The candidate shall be required to submit statement of purpose (SOP) if he/she wish to undertake major project (PHP-520) in final semester (Semester- IV) along with the consent from one of the regular faculty member of the department for supervision (The faculty can give consent to one student only). The SOP will be evaluated by four member's committee chaired by Chairperson along with supervisor as one of the member.

- *The criteria for selection of students for major project (*PHP-520*) in final semester (Semester-IV) is as under:*

iv) *The students must have passed all the lower semester exams (1st to 2nd semester).*

v) *The students merit will be framed as follows:*

   c) *50% weightage from 1st & 2nd semester aggregates marks*

   d) *50% weightage of SOP evaluation*

vi) *maximum 10% of the total strength of students will be selected on merit basis for project.*

- *The guidelines for SOP will be provided by the department.*

- A student opting for major project (PHP-520) is required to undertake 16-20 weeks' (one semester) project in semester IV. He/she is supposed to submit acceptance-cum-recommendation letter from a Faculty from a National level institution /'A' grade University including GJUS&T by the end of IIIrd semester.

The evaluation of major project report & presentation out of 500 marks will be done as follows:

1. *150 marks by the concerned supervisor based on overall internal assessment.*
2. *200 marks through presentation of major project before four member's committee chaired by Chairperson (Each member to award out of 50 marks)*
3. *150 marks by inviting the external examiner in the relevant area.*

The external examiner may be asked to evaluate up to the maximum of 10 students in the relevant area

SEMESTER-III

PHL 511: Nuclear 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The objective of the course on Nuclear Physics is to familiarize the students to the basic aspects of Nuclear Physics like wave mechanical properties of nuclei, electric and magnetic moments, nuclear shapes, nuclear forces, basic properties of neutrons detection, Nuclear reactions, types of reactions and conservation laws.	**Course Outcomes:** After taking the course, students should be able to explain central concepts, laws and models in nuclear physics, interpret basic experiments & can use basic laws and relations to solve related problems

UNIT-I

Nuclear Models: Survey of basic nuclear properties, Liquid drop model, Semi classical mass formula, Mass parabola and valley of stability, Experiment evidence for shell effect, Magic numbers, Shell model, Spin-orbit coupling, Angular momenta and parity of nuclear ground states, Magnetic moments and Schmidt lines, Nuclear Quadrupole moments, Quadrupole moments of deformed nuclei, Rotational and vibration excitation of deformed nuclei.

UNIT-II

Nuclear Decays: Beta decay, Fermi theory of beta decay, Angular momentum and parity selection rules, Shape of the beta spectrum, Total decay rate, Kurie plots, Comparative half-life, Classification of beta transitions, Selection rules for allowed and forbidden transitions, Detection and properties of neutrino, Gamma decay:Electric and magnetic multipole gamma transitions, Angular momentum and parity selection rules, Reduced transition rates (Weisskopf formula), Alpha decay: Giger-Nuttan law and tunnelling theory,Selection rules for alpha decay, Internal conversion, Nuclear isomerism, Interaction of charged particle with matter (qualitative idea).

UNIT-III

Nuclear Interaction: Two Nucleon Problem: Deuteron system, Exchange forces, Meson theory of nuclear forces, Nucleon-nucleon scattering, Effective range theory, Spin dependence and charge independence of nuclear forces.

Nuclear Reaction: Kinematics of nuclear reactions in lab and Centre of mass reference frames, Q value calculation, Concept of Cross section, Type of nuclear reactions, Direct and compound nuclear reactions, Inelastic scattering and transfer reactions, Resonances (Isobaric Analogue, Giant and Molecular), Break-up reactions.

UNIT-IV

Heavy ion reactions: Special features of heavy ions scattering (Q-and L-window), Rainbow and Glory scattering, Quasi elastic and transfer reactions, Complete and incomplete fusion, Fission: Spontaneous fission mass distributions and elementary model, Derivation of spontaneous fission condition for deformed nuclei, Search for Super Heavy Nuclei (qualitative).

Nucleosynthesis in Big-Bang (qualitative idea) and in stars (“r” and “s’’ process), EMC effect (Qualitative), Experimental observations of short range correlations (SRC) between nucleons, Halo Nuclei (qualitative).

Text and Reference Books:

1. Physics of Atomic Nuclei, Vladimir Zelevinsky, Wiley-VCH, 2017
2. The Atomic Nucleus, J.M. Reid, Penguin Books, 1972
3. Kenneth S. Krane, Introductory Nuclear Physics, Wiley, New York, 1988
4. R.R.Roy and B.P.Nigam, Nuclear Physics, Wiley-Eastern Ltd., 1983
5. Nuclear Physics, S. B. Patel, New Age publication
6. Basic Ideas and Concepts in Nuclear Physics: K. Heyde, (Overseas Press India) (2005).
7. Nuclear Physics: Experimental and Theoretical: H. S. Hans, (New Academic Science Ltd., Second Revised edition) (2010).

PHL 512: Electrodynamics

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The main objective of this course is to understand of theoretical fundamentals of Electrodynamics and physics of plasma i.e. electromagnetic fields the one side and the interaction of charges and currents with field on other side. This includes solutions of the free wave equations, solutions with stationary sources and solutions to the equations with time dependent charge and current distributions. This also emphasis on the study of the radiation phenomena and basic concepts of plasma.	**Course Outcomes:** The intention of this part of the lectures is to analyze the fundamentals of electrodynamics on the basis of Maxwell’s equations. The idea is to examine solutions of Maxwell’s equations under different types of conditions. Ability to analyze electromagnetic problems and to apply mathematical methods for solving.

UNIT-I

Electromagnetic waves in a homogeneous medium-solution for free space conditions; Uniform plane waves;Wave equations for a conducting medium; Wave propagation in a loss less medium;Wave propagation in a conducting medium;Wave propagation in a good dielectric;Lorentz Invariance in Maxwell's Equations; Transformation of electromagnetic fields.

UNIT-II

Polarization: Linear, elliptical and circular Polarization; Direction cosines; Reflection and refraction of electromagnetic plane waves: Reflection by a perfect conductor – normal and oblique incidence; Reflection by a perfect dielectric – normal and oblique incidence; Power loss in a plane conductor; Polarization by reflection.

ScatteringandDispersion; Thomson Scattering, Rayleigh scattering, Coherent and Incoherent Scattered Light, Polarization of Scattered Light, Dispersion in Solids, Liquids and gases.

UNIT-III

Lienard–Wiechert Potentials and field for a point charge, Field of a charge in arbitrary motion and uniform motion;Power radiated by an accelerated charge: Larmor Formula and its relativistic generalization, Angular Distribution of Radiation emitted by anacceleratedcharge;Radiation emitted by charge in arbitrary motion; Bremsstrahlung, Synchrotron Radiation and Cerenkov radiation, Reaction Force of Radiation.

UNIT-IV

Elementary Concepts: Plasma Oscillations, Debye Shielding, Plasma Parameters, Magneto plasma;Plasma confinement. Waves Guides;Modes in rectangular waveguides and Dielectric Slab Wave guide;Energy flow and attenuation in waveguides; Concept of Cut off frequency; Resonant cavities; Power losses in a cavity.

Reference Books:

1. Classical Electrodynamics: J.D. Jackson, (Wiley Eastern, New Delhi) (1998).

2. Introduction to Electrodynamics: D.J. Griffiths, (Prentice Hall India, New Delhi) (2008).

3. Classical Electrodynamics: S.P. Puri, (Tata McGraw Hill, New Delhi) (2nd edition) 1997,

4. Plasma Physics: Bittencourt
5. Plasma Physics:Chen

PHL 513: Computational 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: The present course is focused on efficient use of computer languages for solving physics problems/ Formulae using different numerical methods in FORTRAN.	***Course Outcomes:*** After completion of this course, students will be able to understand the various numerical methods used in simulation and modelling in Physics. The students are also able to match the experimental results in physics with theory using these numerical tools.

UNIT- I

Interpolation and Extrapolation: Finite differences, Newton Forward and Backward formulas, Central differences, Stirling's formula, Lagrange's interpolation formula, Hermite's interpolation formula. Least square curve fitting: The principle of least square fitting, Linear regression, Polynomial regression, Fitting exponential and trigonometric functions, Data fitting with cubic splines.

Solutions of simultaneous linear algebraic equations: Gauss elimination method, Gauss Jordan elimination method, Matrix inversion method, Gauss Seidel iterative method, Matrix eigenvalues and eigenvectors: Polynomial method, Power method.

UNIT - II

Differentiation and Integration: Taylor series method, Newton's forward and backward difference formula, Stirling's formula, Trapezoidal rule, Simpson's 1/3 rule, Gaussian Quadrature, Legendre–Gauss Quadrature, Numerical double integration.

Numerical solution of differential equations: Taylor's series method, Euler and modified Euler's method, second and Forth-order Runge Kutta method, Numerical Solutions of Partial Differential Equations using Finite Difference Method.

UNIT III

Random numbers: Random number generators, Mid-square methods, Multiplicative congruential method, mixed multiplicative congruential methods, Modeling radioactive decay. Hit and miss Monte-Carlo methods, Monte-Carlo calculation of π, Monte-Carlo evaluation of integration, Evaluation of multidimensional integrals; Chaotic dynamics: Some definitions, The simple pendulum, Potential energy of a dynamical system. Portraits in phase space: Undamped motion, Damped motion, Driven and damped oscillator.

UNIT– IV

Simulation of physics problems: Algorithms to simulate interference and diffraction of light, Simulation of black body radiation problem, Simulation of charging and discharging of a capacitor, current in LR and LCR circuits, Computer models of LR and LCR circuits driven by sine and square functions, Computer model of Rutherford scattering experiment, Simulation of electron orbit in H_2 ion. Simulation of spectral series in hydrogen atom. Particle in one dimensional box. Simulation of Radial Schrodinger equation for Hydrogen atom.

Reference Books:

1. Fortran 77 and Numerical Methods. C. Xavier New Age International 1994.
2. R C Desai, Fortran Programming and Numerical methods, Tata McGraw Hill, New Delhi.
3. Suresh Chandra, Computer Applications in Physics, Narosa Publishing House.
4. William H. Press, Saul A Teukolsky, William T Vellerling and Brain P. Flannery, Numerical Recipes in Fortran, Cambridge University Press.
5. M L De Jong, Introduction to Computation Physics, Addison-Wesley publishing company.
6. R C Verma, P K Ahluwalia and K C Sharma, Computational Physics an Introduction, New Age International Publisher.
7. S SSastry Introductory methods of numerical Analysis, Prentice Hall of India Pvt. Ltd.
8. V Rajaraman, Computer Oriented Numerical Method, Prentice Hall of India Pvt. Ltd.
9. C Balachandra Rao and C K Santha, Numerical Methods, University Press
10. K E Atkinson, An introduction to numerical analysis, John Wiley and Sons.

PHL 514 (i): Materials Science-I

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: This course has been formulated to introduce students to various types of defects and dislocations in crystals. The students shall be able to analyse optical properties and optical processes thus involved. They should also be able to analyse various types of disordered systems and different types of solid surfaces.	**Course Outcomes:** After completing this course, students would be able to deal with various types of defects found in crystals; their optical properties; disordered systems and analysis of solid surfaces

UNIT – I

Defects in crystals : Point Defects: vacancy, substitutional, interstitial, Frenkel and Schottky defects, equilibrium concentration of Frenkel and Schottky defects; Line Defects: slip planes and slip directions, edge and screw dislocations, Burger's vector, cross-slip, glide and climb, jogs, dislocation energy, super & partial dislocations, dislocation multiplication, Frank-Read sources; Planar Defects: grain boundaries and twin interfaces; Dislocation Theory – experimental observation of dislocation, dislocations in fcc, hcp and bcc lattice.

UNIT – II

Optical properties of crystals: Dielectric function of the free electron gas, Plasma optics, Dispersion relation for Electromagnetic wave, Transverse optical modes in plasma, Longitudinal plasma oscillations, Plasmons, Screened Coulomb potential, Pseudopotential component, Mott metal-insulator transition, screening and phonons in metals, Polaritons, electron-electron interaction, fermi liquid, electron-phonon interaction; polarons. Optical Processes: Optical reflectance, Kramers-Kronig Relations, Electronic Interband transitions, Excitons, Frenkel excitons, Mott-Wannier excitons, Excitons condensation into electron-hole drops, Electron spectroscopy with X-rays, Energy loss of fast particles in a solid.

UNIT – III

Disordered systems: Disorder in condensed matter -substitutional, positional and topographical disorder; Short- and long-range order; Atomic correlation function and structural descriptions of glasses and liquids; Anderson model; mobility edge; Minimum Metallic Conductivity, Qualitative application of the idea to amorphous semiconductors and hopping conduction. Various types of glasses and their applications. Glass ceramics.

UNIT-IV

Solid Surfaces and Analysis: Surface and its importance, selvedge depths of surface; Methods of Surface Analysis: Auger Electron spectroscopy (AES)- basic principle, methodology, composition analysis and depth profiling; X-ray photoelectron spectroscopy (XPS) or ESCA: principle, methodology and quantitative analysis; Glancing angle X-ray Diffraction (GXRD), basic concept, methodology and structural analysis; Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM): Principle, methodology and Applications in surface analysis; Atomic Force Microscopy (AFM): Basic principle, Methodology, applications in structural analysis.

Reference Books:

1) Material Science by J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings'
2) Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
3) Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
4) Solid State Physics, Mermin and Aschcrofft.
5) Fundamentals of Surface and Thin Film Analysis, L.C. Feldman and J. W. Mayer
6) Surface Analysis Methods in Material Science, D. J. O'Connor, B. A. Sexton and R. St. C. Smart (Eds), Springer Series in Surface Sciences 23

PHL 514 (ii): Photonics-I (Fibre Optics and Communication)

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The course on Fiber Optics and optical communication deals with Semiconductor Physics as it acts as the optical source in Optical communication. To make understand the idea of various types of Detectors and noise associated with detectors for improving signal to noise ratio. Optical Fiber as transmission medium, dispersion in waveguides, Attenuation are the key features of the contents	**Course Outcomes:** After introducing the idea of Light propagation through Optical waveguide, Optical sources and detectors, the student will be able to understand the concept of design of Optical communication system considering the time budget and power budget. Understanding the concept of fiber laser is important to the requirement beyond conventional lasers.

UNIT-I

Optical Sources & Detectors: General description, Laser structure, Excitation Mechanism of the Semiconductor Laser Diode and light emitting Diode, Radiative recombination in semiconductor materials, Semiconductor density of states, Occupation probability, Optical absorption and Gain, Heterostructure laser, Quantum well lasers, Modulation rates in semiconductor lasers.

Noise in Optical detectors: S/N ratio for optical power and signal currents, Background radiation, Johnson (Thermal noise), Dark current shot noise, 1/f noise, Combined effect of all the noise sources.

UNIT-II

Transmission Medium-Fiber Optics: Principle of fiber optics: Ray optics and wave propagation in infinite slab waveguide, Electromagnetic analysis of the planer waveguide, The longitudinal wavevector, Fiber types: step index and graded index fiber structures, Wave Equations for Step index Fiber, Optical modes and their properties, Number of guided modes in a waveguide, Mode field diameter, Numerical Aperture and propagation modes.

UNIT-III

Dispersion in waveguides: Material dispersion, Modal Dispersion, and waveguide Dispersion and their simultaneous effects. The ray picture of Propagation in a graded Index material: The Eikonal equation, dispersion reduction with a graded index profile and the modal picture.WKB approximation of graded index fiber, Wave equations for Step index circular waveguides, Spatial Modes in Step-index waveguides: TE/TM modes, Hybrid modes and Linearly Polarized modes, Power flow in Step-index fibers.

UNIT-IV

Attenuation and Nonlinear Effects in Waveguides:

Optical fiber Attenuation as a function of wavelength.Intrinsic absorption losses, Mechanical losses, Nonlinear effects in dielectrics, Stimulated Raman Scattering, Stimulated Brillouin scattering, Self-Phase modulation and Optical Solitons. The Optical -Fiber laser.Source to fiber power launching: Source outputs pattern, Power coupling calculation, Equilibrium NA, Lansing scheme for coupling improvement: Non-imaging microsphere. Design issues in a fiber optics communication Link:Power budget, Time budget, Optical repeaters and amplifiers.

Reference Books:

1. Fundamental of Opto-electronics by C.R.Pollock, Irwin (1995)
2. Essentials of Optoelectronics, Alan Rogers,(Chapman & Hall), 1997
3. Optical Fiber Communication by G.Keiser, 2nded.McGRaw Hill
4. Optical communication, M. MukundaRao,Universities Press (2000)
5. Optical Communication, Components & Systems, J.H. Franz &V.k. jain, Narosa (2001)
6. Optical Communication System, W.K.Pratt. (1968)

PHL 514 (iii): Advanced Nuclear Physics-I (Nuclear Models)

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Objectives: The aim and objectives of the course on Nuclear Physics-II is to expose the students of M.Sc. class tothe relatively advanced topics in nuclear models so that they understand thedetails of the underlying aspects and it can prepare them to use all these techniques if they decide to become nuclear physicists in their career.	**Course Outcomes:** After taking the course, students should be able to understand the concepts, laws and frameworks of nuclear structure models.

UNIT-I

Nuclear Shell Model: Coupling of angular momentum, Evidence for nuclear shell structure, Extreme single particle model with square-well and harmonicoscillator potentials, spin-orbit potential, Shell model predictions.
Single-particle model, total spin for various configurations, Nuclear isomerism, Magnetic momentSchmidt lines, electric quadrupole moment,Configuration mixing, Independent particle model, L-S coupling and j-j coupling schemes.

UNIT-II

Collective Model of Nucleus: Rotation - D Matrices, Parameterization of nuclear surface, Collective surface oscillations, Derivation of the collective Hamiltonian, transformation to body-fixed frame, Collective modes of motion, Nuclear vibrations, β and γ vibrations in spheroidal nucleus and associated energy spectra, Iso-scalar vibrations, Giant resonances.
Brief overview supported by examples - Deformed rotational nuclei, rotational energy spectra for even-even nuclei and odd-A nuclei, decoupling parameter, Electric quadrupole moment and magnetic dipole moment, E2 and M1 transition probabilities, Energy spectrum with coupling of vibration and rotational motion.

UNIT-III

Cluster model and IBM: Experimental and theoretical signature of cluster structure in nuclei, Alpha and He-6 cluster model of nuclei, Pairing of nucleons, Evolution of Interactive Boson model (IBM-I, IBM-II etc.), Detail calculations for one of mid-shell nucleus.
Brief Reviews: EMC effect in nuclei, Observation of short ranged correlations between nucleons.

UNIT-IV

Harmonic anisotropic oscillator, Nilsson model, Rotational motion at very high spins, Population of high spin states, cranking shell model, Signature quantum number, Back bending phenomenon, Kinematics and dynamic moment of inertia,
Brief reviews - Nuclear Physics at extremes of stability, nuclear halos, Proton rich nuclei.

Reference Books:

1. Physics of Atomic Nuclei, Vladimir Zelevinsky, Wiley-VCH, (2017)
2. Nuclear Physics: R.R. Roy and B.P. Nigam, (New Age, New Delhi) (2009).
3. Theory of Nuclear Structure: M. K. Pal, (East-west Press, New Delhi) (1992).
4. Nuclear Structure, Bohr & Mottelson, Volume-1&2, World Scientific (1998)

PHL 514 (iv): Theoretical Condensed Matter Physics-I

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: The aim of the course is to familiarize the students with the defects in crystals, semiconductor crystals, Fermi surfaces, optical properties and processes, and about disorder systems in crystals.	**Course Outcomes:** After completion of this course, students will be able to understand the various types of defects in crystals, about Fermi surfaces, optical properties and processes, and about disorder systems in crystals. These topics are very helpful for the students for future research in condensed matter physics.

UNIT – I

Defects in crystals : Point Defects: vacancy, substitutional, interstitial, Frenkel and Schottky defects, equilibrium concentration of Frenkel and Schottky defects**;** Line Defects: slip planes and slip directions, edge and screw dislocations, Burger’s vector, cross-slip, glide and climb, jogs, dislocation energy, super & partial dislocations, dislocation multiplication, Frank-Read sources; Planar Defects: grain boundaries and twin interfaces; Dislocation Theory – experimental observation of dislocation, dislocations in fcc, hcp and bcc lattice.

UNIT – II

Semiconductor crystals: Band gap, Direct and indirect absorption processes, Motion of electrons in an energy band, Holes, Effective mass, Physical interpretation of effective mass, Effective masses in semiconductors, Intrinsic carrier concentration, Intrinsic mobility, Impurity conductivity, Thermoelectric effect, Semimetals, Superlattices.

Fermi surfaces and metals: Fermi surface and its construction for square lattice (free electrons and nearly free electrons), Electron orbits, Hole orbits, Open orbits; Wigner-Seitz method for energy bands, Cohesive energy; Experimental determination of Fermi surface: Quantization of orbits in a magnetic field, De Hass-van Alphen effect.

UNIT – III

Optical properties of crystals: Dielectric function of the free electron gas, Plasma optics, Dispersion relation for Electromagnetic wave, Transverse optical modes in plasma, Longitudinal plasma oscillations, Plasmons, Screened Coulomb potential, Pseudopotential component, Mott metal-insulator transition, screening and phonons in metals, Polaritons, electron-electron interaction, fermi liquid, electron-phonon interaction; polarons.

Optical Processes: Optical reflectance, Kramers-Kronig Relations, Electronic Interband transitions, Excitons, Frenkelexcitons, Mott-Wannierexcitons, Excitons condensation into electron-hole drops, Electron spectroscopy with X-rays, Energy loss of fast particles in a solid.

UNIT – IV

Disordered systems: Disorder in condensed matter -substitutional, positional and topographical disorder; Short- and long-range order; Atomic correlation function and structural descriptions of glasses and liquids; Anderson model; mobility edge; Minimum Metallic Conductivity, Qualitative application of the idea to amorphous semiconductors and hopping conduction. Various types of glasses and their applications. Glass ceramics.

Reference Books:

1) Material Science by J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings'

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

3) Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth

4) Solid State Physics, Mermin and Aschcrofft.

5) Principles of the Theory of Solids (2^{nd} edition) by J. M. Ziman(Cambridge University Press) 1972.

6) Physics of amorphous materials, Longman Group Ltd, London, New york, 1984

PHP 515: Physics Lab-V (Computational Physics Lab)

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

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

1. Each student should perform at-least Ten experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary.

List of Experiments:

1. Numerical integration using (a) Simpson 1/3 and (b) Gauss quadrature methods for one and two dimensional integrals.
2. Least square fitting (Linear).
3. To find eigen values and eigen vectors of a square matrix using power method.
4. Solution of second order differential equation using Runge –Kutta method.
   Application: Eigen values and eigenfunctions of a linear harmonic oscillator using Runge – Kutta method.
5. Solution of simultaneous linear algebraic equations by Gauss Jordan elimination method.
   Application: Illustration of Kirchoff's laws for simple electric circuits.
6. Interpolation and Extrapolation by using Lagrangian method and Newton Forward Interpolation formula.
7. To find the area of a circle by Monte – Carlo technique.
8. Simulation of nuclear radioactivity by Monte- Carlo technique.
9. Simulation of Brownian motion using Monte- Carlo technique.
10. To solve simultaneous linear equations using Gauss –Elimination method.
11. Study of frequency response curve for LCR Circuits.
12. Dynamics of damped driven pendulum.

Open Elective

(To be opted by students of other departments)

PHL 500: Physics for Everyday Life

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: To provide an introduction to popular concepts of Physics in day to day life through constructive critical analysis of physics in sports, light in life, communication and information technology, renewable energy sources etc.	**Course Outcome:** After going through the course, students will be able to know the role of physics behind various phenomenon occurring in our surrounding.

Unit-I

Physics in sports: Swimming - Forces acting on a floating body, Forces acting on a swimmer moving through the water, Dolphin kick. Golf- the Golf Swing, Aerodynamics of Ball flight. Gymnastics- The still rings, Trampoline. Pole Vaulting. Running-Forces generated during running, Path travelled by runners and center of mass, Arm swinging.

Unit-II

Light in Life: Introduction to lasers, its basic characteristics and working, Types of lasers, Application of laser in Industry (cutting, drilling, welding, material processing, etc.), Medicine (skin and eyes cosmetic surgery, Optical coherent tomography, Photo dynamic therapy & other treatments)., Communication (digital and satellite communication, Defence etc.),

Unit-III

Communication & Information Technology- Introduction to Optical fiber Principle working, Types of Fibers, communication: Sources and Detectors, Satellite Communications: Satellite Orbits, Geostationary orbits, Applications of satellite in Communication, Telephones, Television, Radio Broadcasting (AM and FM communication), Military, GPS, Weather forecasting etc.

Unit-IV

Renewable Energy: Solar energy: Solar Cells its types and applications Wind Power, Hydropower, Geothermal energy, Bio energy. Commercialization: Indian Economic Trends, industry & policy trends. Status of Indian energy sector and future plans.

Reference Books:

1. Lasers Fundamentals, W.T. Silfvast, Cambridge (1996)
2. Optical communication, M. MukundaRao,Universities Press (2000)
3. https://www.real-world-physics-problems.com/physics-of-sports.html
4. https://www.topendsports.com/biomechanics/physics.htm
5. http://www.authorstream.com/Presentation/Vedang-711005-application-of-physics-in-sports/
6. http://www.indiaenergyportal.org/overview_detail.php
7. A Review of Solar Energy: Markets, Economics and Policies by Govinda R. Timilsina, Lado Kurdgelashvili and Patrick A. Narbel document for The World Bank Development Research Group Environment and Energy Team, October 2011
8. Solar energy: Principles and possibilities, Science Progress (2010), 93(1), 37–112doi: 10.3184/003685010X12626410325807

SEMESTER-IV

PHL-516: Advance Quantum Mechanics

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: Objective of the current course is to familiarize the students in relativistic quantum mechanics and introductory quantum field theory, finally leading to them to the basics of particle physics.	**Course Outcome:** Students should be able to understand the basic formalism of relativistic quantum mechanics, field theory and introductory particle physics.

UNIT-I

Relativistic Quantum Mechanics: Klein-Gordon equation, Dirac equation and itsplane wave solutions, Properties off Dirac matrices, Significance of negative energy solutions, Spin angular momentum of the Dirac particle, The nonrelativistic limit of Dirac equation, Electron in electromagnetic fields, Spin and magnetic moment of electrons, spin-orbit interaction, Dirac equation for a particle in a central field, Fine structure of hydrogen atom, Lamb shift.

UNIT-II

Quantum Field Theory: Resume of Lagrangian and Hamiltonian formalism of a classical field, Noether theorem, Quantization of real scalar field, complex scalar field, Dirac field and e.m. field and their representations, Covariant perturbation theory of QFT, Wick's Theorem.

UNIT-III

S-matrix formulation, Path Integral formulation of field theory, Feynman rules, Feynman diagrams and their applications, Calculation of scattering cross sections, decay rates, with examples, Quantum Electrodynamics, Calculation of matrix elements - for first order and second order processes.

UNIT-IV

Fermions and bosons, particles and antiparticles, quarks and leptons, Interactions and fields in particle physics, Charge conjugation, Charge, parity and Time reversal invariance, CPT theorem, Cross section and decay rates for hadron-hadron interaction, Pion spin, Isospin, Particle production at high energy.

The Baryon decuplet, quark spin and color, baryon octer, quark-antiquark combinations, Standard Model, Weak Interactions: Classification of weak interactions, Parity non-conservation in β-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K-decay, Relativistic kinematics.

Reference Books:

1. A first book of Quantum Field Theory, A. Lahiri&P. Pal, (Narosa Publishers, Delhi), 2005.
2. Lectures on Quantum Field Theory, A. Das (World Scientific), 2008.
3. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, (Tata McGraw Hill, New Delhi), 2004.
4. Quantum Mechanics: M.P. Khanna, (HarAnand, New Delhi), 2006.
5. Quantum Field Theory: H. Mandl and G. Shaw, (Wiley, New York) 2010.
6. Advanced Quantum Mechanics: J.J. Sakurai (Addison-Wesley, Reading), 2004.

PHL 517 (i): Materials Science-II

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: To make students aware of different types of materials in their bulk and thin film forms and their properties	**Course Outcome:** Students will become aware of various thin film deposition and characterization techniques, Properties of dielectric and ceramic materials in advance applications.

UNIT-I

Mechanical Properties: Stress Strain Curve; Elastic Deformation: atomic mechanism of elastic deformation andanisotropy of Young's modulus, elastic deformation of an isotropic material; Anelastic and Viscous deformation;Plastic Deformation: Schmid’s law, critically resolved shear stress; Strengthening Mechanisms: work hardening,recovery, recrystallization, strengthening from grain boundaries, low angle grain boundaries. yield point. Strain aging, solid solution strengthening, two phase aggregates, strengthening from fine particles; Fracture: ideal fracture stress, brittle fracture-Griffith's theory, ductile fracture.

UNIT-II

Technological Materials: SMART materials - piezoelectric, magnetostrictive, electrostrictive materials - shape memory alloys - rheological fluids - CCD device materials and applications - solar cell materials (single crystalline, amorphous and thin films) - surface acoustic wave and sonar transducer materials and applications.

UNIT-III

Thin Films Deposition and Characterization Techniques: Thin film deposition techniques: Physical methods: thermal evaporation electron beam deposition, sputtering, molecular beam epitaxy – MBE, laser ablation. Chemical methods: chemical vapour deposition and chemical solution deposition techniques - spray pyrolysis and electro deposition. Thickness measurement -Multiple beam interference, quartz crystal, ellipsometric, stylus, Structural, Optical and electrical characterization

UNIT-IV

Crystals Growth and Characterization: Bridgman technique:Czochralski methods - Verneuil technique - zone melting – gel growth – solution growth methods – low and high temperature solution growth methods – vapour growth - epitaxial growth techniques.

Characterization: X-ray diffraction - electron microscopy, Raman spectroscopy

Liquid Crystals: Thermotropic liquid crystals, Lyotropic liquid crystals, long range, various phases of liquid crystals, Effect of electric and magnetic field, Applications and prospects of liquid crystals.

Reference Books:

9. Mechanical Metallurgy by G. E. Dieter
10. Buckley, H.E., Crystal growth, John Wiely and sons, New York,1981.
11. Elwell,D&Scheel, H.J., Crystal growth from high temperature solution, Academic Press, New York,1995.
12. Laudise, R.A. The growth of single crystals, Prentice Hall, Englewood,1970.
13. Ramasamy, P. &Santhanaraghavan. P. Crystal growth processes and methods, KRU Publications, 2000.
14. Milton Ohring, The Materials Science of Thin Films, Academic Press, 2001.
15. Donald L. Smith, Thin-Film Deposition: Principles and Practice, McGraw- Hill, 1995.
16. K.L. Chopra, Thin Film Phenomena, McGraw-Hill, 1969.

PHL 517 (ii): Photonics – II (Nonlinear Optics)

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The main aims of this course are to develop a conceptual understanding of important topics in nonlinear optics at a quantitative level. A key objective is to enable the student to undertake quantitative problem –solving aptitude relating to the design and performance of nonlinear parameters thereby acquiring an ability to put such knowledge into practice by way of numerical calculations.	**Course Outcomes:** Students who complete the course will learn about the non linear optical processes and their applications. This course develops a conceptual understanding of the Maxwell wave approach to non-linear optical interactions. Theoretical basis using coupled mode amplitude equations with the coupling of two or three waves provide understanding of the coupling processes of different waves and their-in energy exchange process.

Unit -1

Introduction to Non-linear Optics: Change in optical properties and generation of new Harmonics; Classical expansion in powers of the field induced polarization (Brief idea), Linear susceptibility; Introduction to second order and third order Non-linear optical processes; Definition of Non-linear susceptibility, Description using classical anharmonic oscillator on parabolic potential well: Centrosymmetric and non-centrosymmetric cases; Miller's Rule, Symmetry properties of Non-linear susceptibilities: Fields, Permutation and Kleinman symmetry aspects, Contracted Notation, Effective Value of d (d_{eff}).

Unit-II

Crystal symmetry and influence on spatial symmetry on second order susceptibility, idea of crystals classes and effects on symmetry and birefringence.

Wave equation for non-linear optical media; Coupled Wave Equations for Sum Frequency generation(using slowly varying amplitude approximation), phase matching conditions, wave vector mismatch, Temperature and Angle tunings for phase matching, Type I and Type II phase-matching;Manley Rowe relations.

Unit-III

Optical Mixing: Coupled wave equations for Second Harmonic Generation and for three wave interactions, Uniaxial crystals and Index Ellipsoid. Difference Frequency Generation and Parametric Amplification, Optical Parametric Oscillators. Four Wave Mixing, Optical phase conjugation, Optical Bistability: Idea of Absorptive and Refractive bistability.

Unit-IV

Self-Action effects: Intensity dependent refractive index, Idea of Self focusing of light, Self-trapping of light and Beam break up.

Electro-optic effect: Pocked and Kerr effects; Pocked effect in KDP crystal, Longitudinal and transverse configurations; Electro-optic modulator, Acousto-optic effect; Acousto-optic modulator, Design of Q switched laser; Methods of Q switching, Theory of mode locking, Methods of mode locking.

Text and Reference Books:

1. Laser Electronics, J.T. Verdeyen, Prentice Hall (1995)
2. Lasers & Electro-Optics: Fundamental & Engineering C.C.Davis, Cambridge (1996)
3. Lasers Fundamentals by W.T. Silfvast, Cambridge (1996)
4. Principles of Lasers, O. Svelto, Plenum (1989)
5. Nonlinear Opticsby R.W. Boyd, (2008)
6. Laser Physics, L.V.Tarasov, Mir (1983)
7. Quantum Electronics, A Yavir, John Wiley (1992)
8. Laser: Theory & applications, A. Ghatak&Tayagrajan, Macmillan India

PHL-517 (iii): Advanced Nuclear Physics-II (Nuclear Reactions)

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The objective of the course on Nuclear Physics is to familiarize the students to the basic aspects of Nuclear reactions, type of reaction, compound and direct reactions, heavy ion reactions, and various reaction models.	**Course Outcomes:** After taking the course, students should be able to explain central concepts, laws and models in nuclear reactions, interpret basic experiments & can use basic laws and relations to understand and predict the outcome of a nuclear reaction.

UNIT-I

Type of nuclear reactions, Centre of mass coordinate system, Energy and mass balance, Cross-sections, Coulomb Scattering: Rutherford formula, Quantum and relativistic effects (qualitative), Electron Scattering, Polarization of target and projectiles, Scattering of identical particles, Partial wave analysis of scattering, Significance of partial waves, scattering matrix and phase shift, scattering amplitude, Total cross section and optical theorem, Penetration and reflection by coulomb barrier, Collisions including spin effects.

UNIT-II

R-matrix and boundary matching theories, Classical and Semi classical description of scattering, (Deflection function, orbits, Rainbow and glories effects), Diffraction and effect of strong absorption (Fraunhofer and Fresnel diffraction approximations), Breit-Wigner Dispersion Formula for Nuclear resonances, Compound Nucleus, Cross-section for formation of compound nucleus, Statistical theory of nuclear reactions, Reaction between heavy ions, Complete and incomplete fusion, Evaporation model of compound nucleus decay.

UNIT-III

Optical model: Optical model for nuclear reactions at low energies, Imaginary potential and absorption, Comparison with experiment results, Limitations of Optical Model.
Direct Reactions: Semi classical model of direct reaction using distorted wave born approximation, Inelastic scattering, Stripping and pickup reaction, Knock-out reactions

UNIT-IV

Nuclear Astrophysics: Fusion in stars, Production of energy and elements in stars, “r’ and “s” process, Fusion reactor (qualitative description)
Nuclear Fission: Types of fission, Fission energy and mass distributions, Fission cross section, Mass and energy distribution of fragments, Spontaneous fission.
Brief reviews - Radioactive ion beams, Production of super heavy nuclei

Reference Books:

1. Introduction to Nuclear Reactions, G.R. Satchler, 2nd edition, Macmillan Education Ltd.
2. Nuclear Physics: Experimental and Theoretical: H. S. Hans, (New Academic ScienceLtd., Second Revised edition) (2010).
3. Nuclear reactions, Paetz gen. Schieck, Hans, Springer Publication (2014)

PHL 517 (iv): Theoretical Condensed Matter Physics-II

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The main objective of this course is to understand theoretical concept of magnetic resonance, surface and interface physics, independent electron approximation and nanostructures and electron transport in condensed matter.	**Course Outcomes:** After going through the contents of course, the students will develop the research endeavour in theoretical condensed matter physics and will also learn the analytical approach for handling the problems.

Unit - I

Magnetic Resonance: Magnetic Resonance, Nuclear Magnetic Resonance, Line Width, Motional Narrowing, Hyperfine Splitting, Nuclear Quadrupole Resonance, Ferromagnetic Resonance, Shape Effects in FMR, Antiferromagnetic Resonance, Electron Paramagnetic Resonance, Principal of Maser Action

Unit - II

Surface and Interface Physics: Reconstruction and Relaxation, Surface Crystallography, Surface Electronic Structure, Thermionic Emission, Surface States, Tangential Surface Transport, Magnetoresistance in a Two- Dimensional Channel, Integral Quantized Hall Effect, IQHE in a Real Systems, Fractional Quantized Hall Effects (FQHE), p-n Junctions, Rectification, Solar Cell and Photovoltaic Detectors, Schottky Barrier, Heterostructures, n-N Heterojunction, Semiconductor Lasers, Light- Emitting Diodes, Scanning Tunnelling Microscopy

Unit-III

Beyond the independent electron approximation: The basic Hamiltonian in a solid: Electronic and ionic parts, Born-Oppenheimer Approximation; The Hartree equations, Connection with variational principle; Exchange: The Hartree-Fock approximation, Hartree-Fock theory of free electrons- One electron energy, Band width, DOS, Effective mass, Ground state energy, exchange energy, correlation energy (only concept); Screening in a free electron gas: The Dielectric function, Thomas-Fermi theory of screening, Calculation of Lindhard response function, Lindhard theory of screening, Friedel oscillations, Frequency dependent Lindhard screening (no derivation).

Unit- IV

Nanostructures and Electron Transport: Nanostructures; Imaging techniques (principle): Electron microscopy (TEM, SEM), Optical microscopy, Scanning tunneling microscopy, Atomic force microscopy; Electronic structure of 1D systems: 1D sub-bands, Van Hove singularities; 1D metals-Coulomb interactions and lattice couplings; Electrical transport in 1D: Conductance quantization and the Landauer formula, Two barriers I n series- Resonant tunneling, Incoherent addition and Ohm's law, Coherence-Localization; Electronic structure of 0D systems (Quantum dots): Quantized energy levels, Semiconductor and metallic dots, Optical spectra, Discrete charge states and charging energy; Electrical transport in 0D- Coulomb blockade phenomenon

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
3. Solid State Physics, Neil W. Ashcroft and N. David Mermin
4. Electronic Structure of Materials by Rajendra Prasad
5. The Wave Mechanics of Electrons in Metals by Stanley Raimes

PHL 518 (i): Physics of Nano Material

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The course gives an overview of Nanoscience & Technology including basics of sensors, quantum dots, Lithography. Fabrication and characterization of nanomaterials is the important component.	**Course Outcomes:** The course is made to understand the need of nanotechnology. Various fabrication and characterization techniques for nanomaterials will help the students for seeking jobs in future industry.

UNIT-I

Introduction: Introduction to Nano science, Historical background & developments, Richard Feynman Statement, Top down and Bottom up approach, Surface to Volume Ratio, Quantum confinement, Size effect in nano system, Quantum dots, Nanowires, Different Allotropes of carbon, Introduction to CNTs, Structure of CNTs, Types of CNTs- SWNTs, MWNTs, Bucky balls (C_{60}), Graphene, Semiconductor Nano particles–types, properties and applications.

UNIT-II

Synthesis Technique: Dry & Wet Etching, Ball Milling, Vacuum technique, Mean free path, Rotary Pump, Diffusion Pump, Vacuum gauges (Pirani & Penning), PVD (Physical vapor deposition) Arc discharge Method, Spin Coating, Dip coating, Langmuir Blodgett Film.

UNIT-III

Characterization & Instrumentation Technique for Nanotechnology: Interaction of electron beam with solid specimen, Introduction to Electron Microscopy: principle and operation of SEM and TEM, EDX, Introduction to Scanning Probe Microscopes (SPM): Principle and operation of STM & AFM, Principle, operation and applications of X -ray Diffraction: XRD, XRF.

UNIT-IV

Applications of Nanomaterials: Effect of Size on Florescence w.r.t. Q.D size, Particle size analyzer: Study of nano impurity in water (PPM) by Atomic Absorption Spectroscopy (AAS). Applications of Nanotechnology in Food, Textile & Medical Science. Biosensor.

Nanotweezers, Lithographic Techniques: AFM based nanolithography and Nano manipulation, Dip pen lithography, Optical Lithography. Role of plants in nanoparticle synthesis basics only.

Books/ References:

1. Introduction to Nanoscience by Gabor L Hornyak and Joydeep Dutta
2. Nanophysics and Nanotechnology by Edward L Wolf
3. Nanotechnology: Principles and Practices by Sulabha K Kulkarni
4. Carbon Nanotubes – Basic Concepts and Physical Properties by Reich S and Maultzsch J
5. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Cao G
6. The Chemistry of Nanomaterials: Synthesis,Properties and Applications by C N R Rao and Achim Müller
7. Nanomaterials by Jinsung Kim
8. Biosensors- Fundamentals and Applications by A P F Turner I Karube and I G Wilson
9. Optical Properties of Metal Clusters by M Vollmer and U Kreibig
10. Hari Singh Nalwa (2011) Encyclopedia of Nano Science &Nanotechnology, American Scientific Publishers.
11. Lüth, Hans 2010 Solid Surfaces, Interfaces and Thin Films. Springer.
12. Vajtai, R 2013. Springer Handbook of nanomaterials, Springer.

PHL 518 (ii): Spectroscopy

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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objectives: The course gives an overview about the spectrographs and monochromators used in various spectroscopic techniques. Key objective is to enable student to learn and understand the different spectroscopic techniques to determine the small absorption in a given medium.	**Course Outcomes:** On completion of the course, the student will develop an understanding for realization of different spectroscopic techniques. It will provide research endeavour in photonics and will also help the students for seeking jobs in optics industry.

Unit I

Spectrographs and Monochromators: Basic Properties, Speed of a Spectrometer, Spectral Transmission, Spectral Resolving Power, Free Spectral Range; Prism Spectrometer; Grating Spectrometer; Interferometers: Basic Concepts of Michelson and Multiple-Beam Interferometers; Plane Fabry-Perot Interferometer, Spectroscopic Comparison between Spectrometers and Interferometers,

Unit II

Advantages of Lasers in Spectroscopy, High-Sensitivity Methods of Absorption Spectroscopy, Frequency Modulation, Intracavity Absorption (single mode); Direct Determination of Absorbed Photons: Fluorescence Excitation Spectroscopy, Photoacoustic Spectroscopy, Optothermal Spectroscopy; Basic concepts of Fourier Transform Spectroscopy

Unit III

Laser Magnetic Resonance, Laser-Induced Fluorescence, Molecular Spectroscopy by Laser-Induced Fluorescence, Experimental Aspects of LIF, Linear and Nonlinear Absorption Spectroscopy, Basic concepts of Saturation and Multiphoton Spectroscopy

Unit IV

Laser Raman Spectroscopy: Basic Considerations, Experimental Techniques of Linear Laser Raman Spectroscopy; Nonlinear Raman Spectroscopy: Stimulated Raman Scattering, Coherent Anti-Stokes Raman Spectroscopy; Basic concepts and application of Time Resolved Spectroscopy

References:

Laser Spectroscopy, W. Demtroder, Springer, 2nd Edition (1996)
An Introduction to Laser Spectroscopy, David L Andrews and A A Demidov Springer
High Resolution spectroscopy by J Michael Hollas, Butterworths.
Lasers Fundamentals, W.T. Silfvast, Cambridge (1996)
Laser Physics, L.V. Tarasov, Mir (1983)
Quantum Electronics, A.Yavir, John Wiley (1992)
Introduction to Laser Physics, K. Shimoda, Springer (1986)
Lasers & non-Linear Optics, B.B.Laud

PHL 518 (iii): Radiation 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 1. The question paper shall contain 20% numerical problems in the relevant papers.

Course Objective: To make students aware of interaction of radiations with matter and different phenomenon associated. How the energy and dose of nuclear radiations affects cells of living beings. The main objective of this course will also be to make students aware of radiation measurement, use of radiation for useful purpose and their effects on biological process.	***Course Objective***: Students will become aware of different phenomenon associated with interaction of radiations with matter and radiations energy and dose measurement, units different types of radiation detectors with principal of working. Students will also be aware of radiological risk and their assessment.

Unit I

Radiation Sources: Radioactivity, Modes of radioactive disintegration, Nature and properties of nuclear radiations, Radioactive decay, Half life time, Source activity, Laboratory sources of nuclear radiation (Alpha source, Beta source and Neutron sources).

Interaction of Radiation with Matter: Modes of interaction: ionization, excitation, elastic and inelastic scattering, Bremsstrahlung, Cerenkov radiation, Concepts of specific ionization, mean free path; Interaction of Light Charged Particles with matter; Interaction of Heavy Charged Particles with matter; Interaction of Electromagnetic Radiations with matter: Photoelectric effect, Compton Scattering, and Pair production; Attenuation of Gamma Radiation: Linear and mass attenuation coefficient; Interaction of Neutrons with matter: elastic scattering, inelastic scattering, capture, and fission.

Unit II

Radiation Detectors and Monitors: Principles of radiation detection; Gas filled radiation detectors: ionization chambers, proportion counters, GM counters, and Spark counter. Scintillation (organic/inorganic) counter; Solid State Detector: Crystal detector, Semi-conductor Detectors (Junction type detector, Lithium drift Germanium detector, Silicon based Pixel & Strip detectors, and HPGe), Neutron Detectors, Thermo – Luminescent Dosimeters (TLD), Chemical detectors (Photographic Emulsions Films), Radiation Monitoring Instruments and Calibration check of radiation monitoring equipment.

Unit III

Radiation quantities and units: Exposure, Dose, Equivalent Dose, Effective Dose, KERMA,, Annual Limit on Intake (ALI), and Derived Air Concentration (DAC).

Biological Effects of Ionizing Radiation: Introduction, Cell Biology: Structure and function of living cell, cell division-mitosis, meiosis and differentiation, central dogma of molecular biology, genetic codes-DNA, RNA and Proteins; Effect of Radiation on Cell: inhibition of cell division, chromosome aberrations, genes mutation, and cell death; Biological effects of Radiation on Human: Somatic Effects (Early effect) and Stochastic effect (Late effect).

Unit IV

Radiation Hazard Evaluation and Control: Radiation Hazard: Internal Hazards and External Hazards; Evaluation and Control of Radiation Hazard, Radiation Shield, Monitoring of External Radiation, Control of Internal Hazard: (i) Containment of Source (ii) Control of Environment

(iii) Contamination (iv) Air Contamination Monitoring (v) Personal Contamination Monitoring (vi) Decontamination Procedures; Radiation Emergency and Preparedness.

Operational Limits: Principles of Radiological Protection: Justification of Practice, Optimization of Practice, and Dose Limitations; Internal Exposure, Dose Limit for (i) Radiation Workers (ii) Public, Occupational Exposure of Women, Apprentices and Students

Production of Radioisotopes and Labelled Compounds: Introduction, Separation of Isotopes, Production of labelled compounds, Specific Activity of labelled compounds, Storage, Quality, and Purity of Radio-labelled compounds.

References:

1. Introduction to Radiological Physics and Radiation Dosimetry, by Frank H. Attix, John Wiley & Sons, 1986.
2. Radiation Detection and Measurement 4th Edition by Glenn F. Knoll
3. Physics and Engineering of Radiation Detection by Syed Ahmed, Laurentian University, Ontario, Canada
4. Measurement and Detection of Radiation, Fourth Edition by Nicholas Tsoulfanidis and Sheldon Landsberger

PHP-519A: PHYSICS LAB-VI (Specialization Lab)

Marks (External) : 70	**Credits : 4**
Marks (Internal Assessment) : 30	**Time : 6 Hrs**

1. Each student should perform at-least Six experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary.

The experiments will comprise related to the specialization opted in Semester-III.

PHP-519B: PHYSICS LAB-VII (Specialization Lab)

Marks (External) : 70	**Credits : 4**
Marks (Internal Assessment) : 30	**Time : 6 Hrs**

1. Each student should perform at-least Six experiments.
2. The students are required to calculate the error involved in a particular experiment.
3. List of experiments may vary.

The experiments will comprise related to the specialization opted in Semester-IV.

PHP-520: Project (Major)

Marks: 500 **Credits: 20**

The candidate shall be required to submit statement of purpose (SOP) if he/she wish to undertake major project (PHP-520) in final semester (Semester- IV) along with the consent from one of the regular faculty member of the department for supervision (The faculty can give consent to one student only). The SOP will be evaluated by four member's committee chaired by Chairperson along with supervisor as one of the member.

- *The criteria for selection of students for major project (*PHP-520*) in final semester (Semester-IV) is as under:*

vii) *The students must have passed all the lower semester exams (1st to 2nd semester).*

viii)*The students merit will be framed as follows:*

e) *50% weightage from 1st & 2nd semester aggregates marks*

f) *50% weightage of SOP evaluation*

ix) *maximum 10% of the total strength of students will be selected on merit basis for project.*

- *The guidelines for SOP will be provided by the department.*

- A student opting for major project (PHP-520) is required to undertake 16-20 weeks' (one semester) project in semester IV. He/she is supposed to submit acceptance-cum-recommendation letter from a Faculty from a National level institution /'A' grade University including GJUS&T by the end of IIIrd semester.

The evaluation of major project report & presentation out of 500 marks will be done as follows:

1. *150 marks by the concerned supervisor based on overall internal assessment.*
2. *200 marks through presentation of major project before four member's committee chaired by Chairperson (Each member to award out of 50 marks)*
3. *150 marks by inviting the external examiner in the relevant area.*

The external examiner may be asked to evaluate up to the maximum of 10 students in the relevant area