University of Lucknow
Master of Physics Programme
Regulations 2020

1. **Applicability**

These regulations shall apply to the Master in Physics programme from the session 2020-21.

2. Minimum Eligibility for admission

A three/four-year Bachelor's degree or equivalent in Science awarded by a University or Institute established as per law and recognized as equivalent by this University with minimum marks: General/OBC 45 %, SC/ST 40% equivalent grade with Physics in final year, shall constitute the minimum requirement for admission to the Master in Physics programme.

3. Programme Objectives

The core objectives of Master of Science programme in Physics:

- ✓ M.Sc. Physics Programme with manifold objectives, is aimed at imparting students with comprehensive knowledge and better understanding in theoretical as well as experimental aspects of physics through the core and elective courses, for holistic development.
- ✓ The core courses have been designed to encourage scientific approach and problem-solving abilities, whereas the elective and open elective courses are structured with specialized and/or interdisciplinary content to equip students with a broader knowledge base.
- ✓ The elective labs are intended for appreciation for the fundamental concepts and working of devices using tools of physics for augmenting Practical and Theoretical knowledge.
- ✓ The Master Dissertation project is intended to give an essence of research work for excellence in specific areas.

4. Programme Outcomes

The prime outcomes of Master of Science programme in Physics:

- ✓ Empowering the students to analyze mathematical models of physical systems and critically analyze the limitations.
- ✓ Promoting the skills of problem solving, developing analytical approach to equip students with improved resilience and matured professional perspective
- ✓ Developing discipline-specific expertise, like self-directed scientific literature analysis, and apply it to pursue their research career.

5. Specific Programme Outcomes

The Master of Science programme in Physics imparts students with:

- ✓ Knowledge to comprehend and appreciate a great variety of phenomena occurring in the Universe, both at micro and macroscopic level in non- relativistic as well as relativistic realm through understanding of basic concepts of Physics.
- ✓ Exposure to research within one of the research areas represented at the Department of Physics, through supervised Master Dissertation project.
- ✓ Adequate analytical skills on the advanced levels of Physics, needed for plethora of job opportunities in education, research, and industry.
- ✓ Competence in core areas of Physics, which is in line with the international standards, aimed at realizing the goals towards skilled India.

6. Course Structure

The course structure of the Master in Physics programme shall be as under:

Course No.	Name of the Couse	Credits	Remark
	Semester I		
PHYCC-101	Atomic and Molecular Physics	04	Core Course
PHYCC-102	Classical Mechanics	04	Core Course
PHYCC-103	Mathematical Physics-I	04	Core Course
PHYCC-104	Electromagnetic Theory	04	Core Course
PHYCC-105	Practical (Optics and Electronics)	04	Core Course
PHYVC-101	Value added course	04	Value added course (Credited)
	Semester Total	24	
	Semester II		
PHYCC-201	Quantum Mechanics-I	04	Core Course
PHYCC-202	Solid State Physics-I	04	Core Course
PHYCC-203	Nuclear Physics-I	04	Core Course
PHYCC-204	Statistical Mechanics	04	Core Course
PHYCC-205	Classical Electrodynamics	04	Core Course
PHYCC-206	General Lab	04	Core Course
PHYVNC-201	Value added course	00	Value added course (Non Credited)
	Semester Total	24	
	Semester III		
PHYCC-301	Quantum Mechanics-II	04	Core Course
PHYCC-302	Nuclear Physics-II	04	Core Course
PHYEL-301A	Electronics-I	04	Elective
PHYEL-301B	Lasers and Optoelectronics-I		
PHYEL-301C	X-Rays-I		
PHYEL-302A	Practical Electronics	04	Elective
PHYEL-302B	Practical Optoelectronics		
PHYEL-302C	Practical X-Rays		
PHYIN-301	Summer Internship	04	Summer Internship
PHYIER-301	Interdepartmental Course	04	Interdepartmental Course
	Semester Total	24	
	Semester IV		
PHYCC-401	Solid State Physics-II	04	Core Course
PHYEL-401	Mathematical Physics-II	04	Elective
PHYEL-402A	Electronics-II	04	Elective
PHYEL-402B	Lasers and Optoelectronics-II		
PHYEL-402C	X-Rays-II		
PHYMT-401	Master Dissertation	08	Master Thesis
PHYIRA-401	Inter/Intra/MOOC	04	Intradepartmental Course
	Semester Total	24	
	GRAND TOTAL	96	

List of Inter/ Intra Departmental M.Sc. Physics Elective Courses offered to the students of M.Sc. Programme.

Credited value-added courses.

Course No.	Name of the Course	Credits	Nature
PHYVC-101	Frontiers of Physics	04	Value-added Credited

Non-credit value-added courses.

Course No.	Name of the Couse	Credits	Nature
PHYVNC-201	Elements of Atmospheric and Space Science	00	Value-added Non-Credited

Inter-departmental value-added courses.

Course No.	Name of the Couse	Credits	Nature
PHYIER-301(A)	Introduction to Electronic Communication	04	Inter-departmental
PHYIER-301(B)	Digital Age	04	Inter-departmental

Intra-departmental value-added courses.

Course No.	Name of the Couse	Credits	Nature
PHYIRA-401(A)	Laser, Optical fibers and Sensors	04	Intra-departmental
PHYIRA-401(B)	Spectroscopic Techniques and Applications	04	Intra-departmental

7. Course Outlines

M.Sc. (PHYSICS) SEMESTER- I
PHYCC-101
ATOMIC AND MOLECULAR PHYSICS

Total Lectures 45 **(4 Credits)**

Course Objectives: To impart the knowledge about the fundamentals of atomic and molecular Physics of the systems, and to describe the structure of atoms and molecules on the basis of quantum mechanics.

UNIT- I

Introduction to Quantum theory, Spin-Orbit interaction energy, Doublet separation, Spectroscopic Description of Atomic Electronic States – Term Symbols, Intensity rules for fine structure doublet, Fine structure of Hydrogen lines. Optical spectra of alkali metals, Non-penetrating and penetrating orbits, Rydberg-Schruster law, Runge's Law, The Ritz Combination Principle, Optical spectra of alkaline earth elements, Singlet and triplet terms. **(10 Lectures)**

UNIT- II

Coupling scheme for two electron systems – non-equivalent and equivalent electron cases, Hund's rule, Lande's interval rule. Normal and Anomalous Zeeman Effect, Paschen-Back effect of one electron system. Hyperfine structure, Isotope effect in atomic spectra, distinction between Isotope effect and hyperfine structure, Normal and inverted terms, Applications of Hyperfine structure, Lamb Rutherford Shift. **(10 Lectures)**

UNIT- III

Microwave Spectroscopy – Rotational spectra, Diatomic and polyatomic molecules, Infrared Spectroscopy – Vibrating diatomic molecule, the diatomic vibrating rotator, Rotation- Vibration spectra of diatomic molecules, Raman Spectroscopy- Pure rotational Raman spectra, Vibrational Raman spectra, Structural determination from Raman Spectroscopy, Selection rules, P.Q and R branches, Isotopic shift. **(10 Lectures)**

UNIT- IV

Electronic Spectra of Diatomic molecules -Breakdown of Born Oppenheimer Approximation, Intensity of Vibrational -Electronic Spectra-The Franck Condon Principle, Dissociation energy and Dissociation Products, Rotational Fine Structure of Electronic-Vibration transitions, The Fortrat diagram, Predissociation, Effect of anharmonicity, Coriolis force.
Coherence-spatial and temporal, He-Ne gas laser, ruby laser, Raman spectroscopy, uses of lasers in Raman spectroscopy, Principle of Electron Spin Resonance (E.S.R), Nuclear Magnetic Resonance (N.M.R), and Nuclear Quadrupole Resonance (N.Q.R.) spectroscopy and their applications. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: After completion of the course students will be able to understand the spectra produced by one and two valence electron systems, intensity of spectral lines and effect of magnetic field on one electron systems as well as origin of hyperfine structure. Students will acquire knowledge of rotational, vibrational and electronic spectra of molecules in addition to acquaintance with the principle of electron spin and nuclear magnetic resonance, nuclear quadrupole spectroscopy and their applications. They will also the Laser principle, basic Lasers and its applications.

Reference Books:

1. Introduction to Atomic Spectra: H.E. White (McGraw Hill, 1934)
2. Atomic Spectra and Atomic Structure: Gerhard Herzberg (Dover Publications 2010)
3. Fundamentals of molecular spectroscopy: C.N. Banwell and E.M. McCash (Tata McGraw Hill 2007)

M.Sc. (PHYSICS) SEMESTER- I

PHYCC-102

CLASSICAL MECHANICS

Total Lectures 45 **(4 Credits)**

Course Objectives: Students will be equipped for advanced and specialized courses. The student learns to deal with particle mechanics at an advanced level and to learn the foundations of the classical theory of fields.

UNIT- I

Mechanics of a system of particles, Constraints, Classification of Constraints, Generalized Co-ordinates, Virtual displacement and principle of virtual work, D'Alembert Principle, Lagrange's Equations, Generalized momenta, Cyclic Co-ordinates, Conservation Laws. **(10 Lectures)**

UNIT- II

Calculus of variation- Euler- Lagrange Equation, Application of Variational Principle, Shortest distance problem, brachistrochrone, Geodesics of a Sphere, Variation under constraints- Lagrange's multipliers, Hamilton's principle, Lagrange's equations from Hamilton's principle, Problems based on Lagrange's equations, Principle of least action. **(10 Lectures)**

UNIT- III

Hamilton's equations and Problems based on it, Canonical Transformation, Generating function, Conditions for canonical transformation and problems, Poisson Brackets and their properties, Invariance of Poisson Bracket under canonical transformation. **(10 Lectures)**

UNIT- IV

Hamilton-Jacobi Equations, Hamilton's principal and characteristic function, Action and Angle Variables, The rigid body motion- Euler Angles, Inertia Tensor and Moment of Inertia, Euler's Equation of motion, Torque free motion of a rigid body, Motion of heavy symmetrical Top, Theory of small oscillations- Free vibration of a linear tri-atomic molecule. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Students who have completed this course will have deep understanding of Lagrangian and Hamiltonian formulation of Mechanical systems and would be able to formulate and solve the Lagrangian and Hamiltonian equations of motion for different mechanical systems.

The students will have deep understanding of variational principle, rigid body motion and theory of small oscillation.

Reference Books:

1. Classical Mechanics: Herbert Goldstein, Addison-Wesley.
2. Introduction to Classical Mechanics: David Morin, Cambridge University Press
3. Mathematical methods of Classical Mechanics: V.I. Arnold, Springer
4. Classical Mechanics**:** G. Aruldhas, PHI learning Private Ltd.
5. Classical Mechanics: Systems of Particles and Hamiltonian Dynamics:
   Walter Greiner, Springer.

M.Sc. (PHYSICS) SEMESTER- I

PHYCC-103

MATHEMATICAL PHYSICS- I

Total Lectures 45 **(4 Credits)**

Course Objectives: The primary objective is to teach the students basic mathematical methods that will be used in many of the other courses in the M.Sc. syllabus.

UNIT- I

Fundamental laws of Algebra on complex numbers, polar form of complex numbers, Properties of moduli and arguments, Regions in the complex plane**)** Continuity and differentiability of complex functions, Analytic (regular) functions, The Cauchy-Riemann equations, Polar form of Cauchy-Riemann equations Laplace's equations, Harmonic functions, Entire function, Branch cuts and branch points, Problems on the above topics. **(10 Lectures)**

UNIT- II

Line integral in complex plane, Cauchy's theorem, Morera's theorem**)** Cauchy's integral formula, Taylor's and Laurent's expansions, Liouville's theorem, singularities, Zeroes and poles Residue theorem and contour integration of simple functions, Jordan's lemma, Problems on the above topics. **(10 Lectures)**

UNIT- III

Ordinary point and singularities of a linear differential equation Power series, solution of second order differential equations (Hyper- geometric, Bessel, Legendre, Laguerre and Hermite equations Orthonormality, Rodrigue's formula and other properties of Legendre, Associated Legendre, Bessel Hermite and Laguerre polynomials**,** its applications in Physics. **(10 Lectures)**

UNIT- IV

Methods of numerical analysis: Finite difference with equal and unequal intervals, Interpolation formulae, Errors and accuracy tests in numerical analysis, the iterative algorithms for solving equations and finding roots Discrete Fourier Transform, Fast Fourier Transform with its advantages in sciences. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Students will learn the required mathematical techniques that may have not been covered in the courses in B.Sc. CBCS programme and which will be useful in many other courses in M.Sc.

Reference Books:

1. Advanced Engineering Mathematics: Erwin Kreyszig
2. Applied Mathematics for Engineer & Physicists: Louis A. Pipes & Lawrence R Harvill
3. Mathematical Methods for Physicists: G. Arfken
4. Mathematical Physics: V. Balakrishnan
5. Mathematical Physics: B.D. Gupta
6. Mathematical Physics: B.S. Rajput
7. Mathematical Physics: H.K. Das & Rama Verma
8. Introductory methods of Numerical Analysis: S.S. Sastry
9. An Introduction to Numerical methods and analysis: Jmes F. Eppeson

M.Sc. (PHYSICS) SEMESTER- I

PHYCC-104

ELECTROMAGNETIC THEORY

Total Lectures 45 **(4 Credits)**

Course Objectives: The primary objectives of this course aim at acquiring the stimulating knowledge of dynamical inter-relationship of electric and magnetic fields and their unification in creating electromagnetic waves, in an interesting way. Students must understand the concepts of electromagnetic wave propagation in vacuum, conducting and non-conducting media and also must be able to identify, formulate and solve fields equations and handle various problems of transporting energy or information in vacuum and through guided structures.

UNIT- I

Maxwell's Equations in vacuum and matter, Maxwell's correction to Ampere's law for non-steady currents and concept of Displacement current, Boundary conditions for electromagnetic fields, Poynting's theorem, Conservation of energy and momentum for a system of charged particles and electromagnetic field. **(10 Lectures)**

UNIT- II

Vector and scalar potentials, Maxwell's Equations in terms of Electromagnetic Potentials, Electromagnetic wave equation, Non-uniqueness of Electromagnetic Potentials and Concept of Gauge. Gauge Transformations: Coulomb and Lorenz Gauge, Transformation Properties of Electromagnetic Fields and Sources under Rotation, Spatial Inversion and Time-Reversal.

(10 Lectures)

UNIT- III

Propagation of Electromagnetic Plane Waves in Vacuum, Non-conducting Medium, Conducting Medium and Plasma, Reflection, Refraction and Polarization of Electromagnetic Waves, Fresnel Formulae, Total internal reflection and critical angle, Frequency Dispersion Characteristics of Dielectrics and Conductors; Normal and Anomalous Dispersion, Kramer Kronig Relations.

(10 Lectures)

UNIT- IV

Basic concept of waveguide, Propagation of Electromagnetic Waves in Rectangular Waveguides, TE and TM Modes, Cut off frequency, Energy Flow and Attenuation. Modal Analysis of guided modes in a cylindrical waveguide, Cavity resonator, Radiation due to electric and magnetic dipoles. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: After attending this course, students would be able to apply knowledge of mathematics and physics in understanding the coupled nature of electromagnetic fields. The role of different coordinate systems and vector calculus to describe the electromagnetic quantities as functions of space and time will be understood. Students will be able to explain fundamental laws governing electromagnetic fields and evaluate the physical quantities of electromagnetic fields (Field intensity, Flux density etc.) in different media. They would appreciate that the Maxwell's equations as field equations do not include the equation of motion of charged particles (say, unlike gravity). As a fundamental curiosity, students will realize which quantities are real and gauge invariant-- (fields or the potentials?) -- in description of reality. Students will also be able to understand the interesting nature of electromagnetic wave propagation in vacuum, conducting and non-conducting media, and understand how these waves are used as means of transporting energy, momentum or information in waveguides for communication.

Reference Books:

1. Introduction to Electrodynamics: David J. Griffiths (Prentice-Hall of India, New Delhi).
2. Classical Electrodynamics: John David Jackson (Wiley India).
3. Theory and Problems of Electromagnetics: Joseph A. Edminster (Tata Mc Graw Hill).
4. Electricity and Magnetism: E.M. Purcell (Berkeley Physics Course , Vol II, Mc Graw-Hill).
5. Foundations of Electromagnetic Theory: J. R. Reitz, F. J. Milford and R. W. Christy (Pearson).

M. Sc. (PHYSICS) SEMESTER- I

PHYCC-105

OPTICS AND ELECTRONICS **(4 Credits)**

Course Objectives: The main objective of this course is to make the students not only understand and perform the Optics and Electronics experiments, but also suitably correlate them with the corresponding theory, through the standard set of experiments.

S.No.	Experiments
1.	Michelson Interferometer
2.	Etalon
3.	Edser Butler
4.	Polarization
5.	Babinet Compensator
6.	S.C.R.
7.	IC Regulated Power Supply
8.	Negative Feed Back
9.	Ultrasonic Interferometer
10.	Modulation & Demodulation

Course Outcomes: At the end of this laboratory course, each and every student is expected to understand the basic concepts of Optics and Electronics through experiments. Recording data, plotting of graphs, extraction of relevant information from graphs and identifying the sources of experimental error is also a key outcome along with analyzing and presenting experimental findings through written laboratory reports.

Reference Books:

1. Advanced Practical Physics for Students: B.L. Worsnop & H.T. Flint
2. Fundamentals of Optics: Francis Jenkins, Harvey White
3. Geometrical and Physical Optics: RS Longhurst
4. Principles of Optics: Born and Wolf
5. Electronic Devices and Circuit Theory: Robert L. Boylestad
6. Integrated electronics: Millman and Halkias
7. Solid State Physics: Streetman
8. Electronic Principles: Albert Malvino and David bates (Eighth edition)
9. Electronic Communication systems: Kennedy

M. Sc. (PHYSICS) SEMESTER- I

PHYVC-101

FRONTIERS OF PHYSICS

Total Lectures 45 **(4 Credits)**

Course Objectives: Physics, whether we acknowledge or not is an integral part of daily existence. Physics is associated with the origin of life itself. As a value added course, this paper focusses on various aspects of Physics encompassing a dimensionality ranging from large multidimensional universes to nanoscales. This course also addresses the vital topic of climate change and how Physics can be used to address it. The student shall be able to appreciate the latest areas of research and applications pertaining to Physics as well as develop a scientific temper and contribute significantly in saving the environment.

UNIT- I

Space and Time, Einstein's Special and General Relativity, Unified reality, Does time flow?, Strings and all that, The elegant universe, Black holes, Dark matter. **(10 Lectures)**

UNIT- II

Basics of Nanotechnology, Application in medicine, Nano-therapy for combating cancer, What is green nanotechnology? Multi-dimensional impact of nanotechnology on health, nanotechnology in warfare, nano art, nano electronics, nano bots. **(10 Lectures)**

UNIT- III

The quantum world, Basic idea of probability, concept of continuous and discrete, quantum healing, quantum computation, quantum biology, QUBITS the new buzzword. **(10 Lectures)**

UNIT- IV

The Physics of climate change, structure of the atmosphere, composition of the earth's atmosphere, the ozone problem, greenhouse gases, carbon footprints and how to minimize them, factors controlling climate. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: At the end of the course the student will be able to appreciate Physics at a fundamental science and to understand the working of the world around us.

M. Sc. (PHYSICS) SEMESTER- II

PHYCC-201

QUANTUM MECHANICS- I

Course Objectives: The primary objective is to equip the students with the knowledge of fundamental concepts and tools of quantum mechanics.

UNIT- I

Journey from Classical to Quantum Mechanics, Concept of normalized and orthogonal wave functions, expectation value of a dynamic variable, Equation of continuity, Coordinate and momentum representation, Schrodinger equation in momentum representation, Uncertainty Principle and its applications, Schwarz inequality and Uncertainty Relation. Hilbert space, Introduction to Dirac's bra-ket notation. **(10 Lectures)**

UNIT- II

Operator formulations, Hermitian operators and their spectrum, Projection operator, Parity operator, Commuting operators, Eigen values and eigen functions of Linear harmonic oscillator by Schrodinger equation and by operator method. Motion in a central field, Schrodinger Equation in spherical coordinates, Hydrogen atom problem, Eigen values and eigen functions of angular momentum operators L^2 and L_z, Spherical harmonics.

(10 Lectures)

UNIT- III

Linear vector spaces and transformations, Special Matrices, Transformation and Diagonalization of matrices. Matrix Formulation, Equations of motion: Schrödinger, Heisenberg and Interaction pictures. Quantization of Classical system, motion of a particle in electromagnetic field, Matrix theory of Harmonic oscillator. **(10 Lectures)**

UNIT- IV

Approximation Methods for Stationary Systems: Time-independent perturbation theory - (a)non-degenerate and (b) degenerate, Variational Method; WKB method and its applications. Time Dependent Perturbation theory, Transition to a continuum of final states-Fermi Golden Rule, Applications, Semi-Classical theory of radiation. **(10 Lectures)**

UNIT- V (OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Students will learn the basic concepts of Quantum mechanics which applies to all the physical systems irrespective of their size and can be beautifully perceived at atomic and subatomic level. Students will be able to understand the various operators used to represent dynamic variables. The eigen values and eigen functions of linear harmonic oscillator and Hydrogen atom will help students to understand the behaviour of microscopic systems.

Reference Books:

1. Quantum Mechanics: B.H. Bransden & C.J. Joachain (Pearson, 2000)
2. Quantum Mechanics: Concepts and Applications: Nouredine Zettili (Wiley, 2016)
3. Introduction to Quantum Mechanics: David J Griffiths (Pearson,2015)
4. Quantum Mechanics -Theory and Applications: Ajoy Ghatak (Trinity, 2015)
5. Principles of Quantum Mechanics: R. Shankar (3rd Ed., Springer, 2008)
6. Modern Quantum Mechanics: J.J. Sakurai (Addison-Wesley, 1993)
7. Quantum Mechanics: Eugen Merzbacher (3rd Ed., Wiley, 1997)

M. Sc. (PHYSICS) SEMESTER- II

PHYCC-202

SOLID STATE PHYSICS- I

Total Lectures 45 **(4 Credits)**

Course Objectives: Knowledge of the role of Solid State Physics in important technological development.

UNIT- I

Lattice Dynamics: Linear Mono- and diatomic chains, Acoustic and optical Phonons, Phonon dispersion spectra for three dimensional monatomic solids, Density of states, Phonon branches in 3-d solid with a polyatomic basis, Local phonon modes, Inelastic scattering by phonons, Experimental measurements of phonons, Phonon heat capacity, Einstein Model, Debye model and Born cut-off procedure, Thermal conduction: lattice thermal conduction and phonon free path, anharmonic effects, Normal and umklapp process**.** **(10 Lectures)**

UNIT- II

Free Electron Theory: Electrical conductivity, Sommerfeld's; Wiedmann-Franz law, Lorentz number, Motion in magnetic fields, Plasmons, Plasma optics, Dispersion relation for electromagnetic waves, Transverse and longitudinal modes , Transparency of alkali halide crystals in ultraviolet light, Screening effect, Mott metal-insulator transition , Polaritons, Electron-electron interaction, Electron-phonon interaction, Polarons. **(10 Lectures)**

UNIT- III

Semi-conductors: Lattice properties of 4th group elements: Structure, physical constants, influence of impurities, diffusion of impurities, Influence of lattice defects, Fermi level and electron-hole distribution in energy bands, Simplified and improved models for insulators and intrinsic semiconductor, Models of an impurity semi-conductor, Temperature dependence of Fermi level in an extrinsic semi-conductor, Conductivity and Hall effect in semi-conductors, Effect of temperature and impurities in semi-conductors, Rectification, Schottky barrier, Heterostructures. N-N heterojunction. semiconductor, Introduction to amorphous semi-conductors. **(10 Lectures)**

UNIT- IV

Superconductivity: Concept of superconductivity, Meissner effect, Type I and type II superconductors, Energy gap, Isotope Effect, London equations, Penetration depth, Coherence length, Super-conductivity ground state, BCS theory, Flux quantization in a ring, Electron tunneling, Giaver's Tunneling, DC & AC Josephson Effect, Macroscopic quantum interference, SQUID, Introduction to high T_c super-conductors. Dislocation in Solids: Dislocations, Edge and screw dislocations, Burger vectors, Dislocation stress and strain, Fields of dislocations, Dislocation multiplication. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: After completing this course, student will be able to know how lattice vibrations are helpful in study of properties of solids such as the heat capacity, conduction etc. They will also learn about the distribution of electrons in metals, semiconductors and insulators and gain familiarity with the concept of superconductivity and their applications.

Reference Books:

1. Introduction to Solid State Physics: C. Kittel
2. Solid State Physics: N. W. Ashcroft and N. D. Mermin
3. Solid State Physics: A. J. Dekker
4. Problems and solutions in Solid State Physics: S.O. Pillai

M. Sc. (PHYSICS) SEMESTER- II

PHYCC-203

NUCLEAR PHYSICS- I

Total Lectures 45 **(4 Credits)**

Course Objectives: The primary objective is to introduce the basic ideas and concepts of Nuclear Physics and impart knowledge about nuclear basic properties, nuclear decays and nuclear reactions.

UNIT- I

Basic facts about nuclei, Mass and binding energy, Semi-empirical mass formula, Nuclear size determination using mu-mesic X-rays and scattering of fast electrons, Nuclear spin and magnetic moment of nuclei, Molecular beam resonance method, Nuclear induction method, Electric quadrupole moment. **(10 Lectures)**

UNIT- II

Alpha decay, Alpha spectra, Selection rules, Geiger-Nuttall relation, Theory of alpha decay, Beta-spectra, Fermi's theory of beta decay, Sergeant's law, Kurie Plot, Allowed and forbidden transitions, Fermi and Gamow Teller Transition, Extraction of Fermi constant, Parity violation in beta-decay, Detection of neutrino. **(10 Lectures)**

UNIT- III

Gamma emission, Multi-polarity of gamma rays, Selection rules, Theoretical prediction Transition probability, estimation of transition probability for single particle (Weisskopf unit), Internal conversion, Angular correlation, Nuclear isomerism, Mossbauer Effect and its applications. **(10 Lectures)**

UNIT- IV

Nuclear reactions, Conservation laws, The Q-equation and deduction of nuclear energy, Compound nucleus, Bohr hypothesis, Resonance phenomenon, Breit-Wigner single level formula, Optical model, Simple discussion of direct reactions. Nuclear fission, Bohr-Wheeler theory of nuclear fission, Controlled chain reaction, Nuclear reactors, Nuclear Fusion.

(10 Lectures)

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: The present course in nuclear physics revolves around many important and crucial aspects of science satisfying the natural human curiosity about the nature. The study regarding the properties of matter at the nuclear scale will provide better insight for understanding of the stability of matter and evolution of the Universe as such. The knowledge of energetics of the nuclear reactions gives not only the insight regarding the feasibility of reaction yield at different energies but could be extended to the Planks Scale also. Many of the scientific advancements related to human health, energy production and industrial requirement etc., are inevitably linked to the basic research in nuclear physics at all levels.

Reference Books:

1. Nuclear Physics: Krane K.S., Wiley India Pvt. Ltd., (2008).
2. Nuclear physics principles and applications: Lilley J.S., John Wiley & sons Ltd.,
3. The Atomic Nucleus: Evans R. D. Tata McGraw Hill, 1955.
4. Atomic and Nuclear Physic: S N. Ghoshal, Vol. II.,2000.
5. Nuclear Physics: R. R. Roy and B. P. Nigam, Wiley-Eastern Ltd. 1983.
6. Introduction to Nuclear Physics: Wong, PHI.
7. Introduction to Nuclear and Particle Physics: A Das and T Ferbel.

M.Sc. (PHYSICS) SEMESTER- I

PHYCC-204

STATISTICAL MECHANICS

Total Lectures 45 **(4 Credits)**

Course Objectives: Statistical mechanics is an indispensable tool for studying physical properties of matter "in bulk" on the basis of the dynamical behavior of its "microscopic" constituents. This course is designed to teach the phenomenological postulates and theories of the matter and their relationship with the quantum mechanics.

UNIT- I

Quantum statistical mechanics of identical particles, Condition for statistical equilibrium, Symmetry of wave function, Postulate of equal a prior probability, Random walk, Ensemble in quantum statistics, Grand Canonical Ensemble, Partition function, Quantum distribution functions (Bose-Einstein and Fermi- Dirac), Derivation of distribution laws using grand partition function.

(10 Lectures)

UNIT- II

Derivation of energy and pressure of Boson gas, Degeneracy of Boson gas, Applications of Bose-Einstein statistics, Bose-Einstein condensation, Planck's Radiation law, Properties of liquid He II, Super fluidity in liquid He II, Tisza's two fluid model, Energy and pressure of Fermi gas at absolute zero, Fermi energy as a function of temperature, Thermodynamic properties of an electron gas.

(10 Lectures)

UNIT- III

Application of statistical mechanics, Rotating bodies, The probability distribution for angular momentum and angular velocities of rotation of molecules, Statistical interpretation of thermo dynamic functions in terms of the grand partition function, Gibbs Paradox, White Dwarf and Chandra Shekhar limit. **(10 Lectures)**

UNIT- IV

Phase transition: First and second kind of phase transition, Gibb's phase rule, One dimensional Ising model, Fluctuations, Mean value of fluctuations, Energy fluctuations in canonical ensemble and concentration fluctuations in grand canonical ensemble, Nyquist theorem (derivation and its applications), Thermodynamics of irreversible processes, Onsager reciprocal relations, Phenomenological coefficient, Principle of minimum entropy production. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: On completion of the course students will have understanding of Physics of equilibrium systems, Fermi and Bose systems, Bose-Einstein condensation and Phase transitions, magnetism and super fluids, and critical phenomena.

References Books:

1. Statistical Mechanics: Kerson Huang, (Wiley)
2. Statistical Mechanics: R. K. Pathria, (Butterworth Heinemann)

M.Sc. (PHYSICS) SEMESTER- II

PHYCC-205

CLASSICAL ELECTRODYNAMICS

Total Lectures 45 **(4 Credits)**

Course Objectives: The course aims to provide, in an exciting manner, the knowledge and problem solving ability in advanced electrodynamics as a mathematical (with tensor algebra and calculus) and conceptual basis (action principle etc.) for other classical field theories in physics. The emphasis would be on the unification of electromagnetic fields, and the Lorentz invariance of the Maxwell's equations as a revolutionary starting point of special theoryrelativity for unifying space and time. The course also aims at understanding causes, nature and effects of radiation and characteristics of various scattering processes to look into the heart of matter.

UNIT- I

Homogeneous and inhomogeneous (Poincare) Lorentz groups, Pseudo-Euclidean spacetime, Spacetime rotations, rapidity, Proper, improper, orthochronous, antichronous Lorentz groups, Light cone and Matrix representation of Lorentz transformations, Spacelike, time like and light like Four-vectors, orthogonality, Four-tensors, Contravariant and Covariant tensors, Trace of a tensor, Contraction, Symmetric and Antisymmetric tensors, Inner and outer products, Quotient Law, Metric tensor, Pseudo tensors, completely antisymmetric unit tensor of rank four, four-velocity, four-momentum, four-acceleration, Minkowski force. **(10 Lectures)**

UNIT- II

Covariant form of continuity equation, 2-Form electromagnetic field-strength tensor, dual field-strength tensor, Covariant formulation of Maxwell's field equations with gauge invariance, Lorentz force equation in covariant form, Transformation of electromagnetic fields as tensor components, Proca Lagrangian with Photon mass, Canonical approach to electrodynamics, Lagrangian and Hamiltonian formulation for a relativistic charged particle in external electromagnetic field, Canonical and Symmetric Stress Tensors, Solution of the wave equation in covariant form. **(10 Lectures)**

UNIT- III

Retarded and advanced potentials, Lienard-Wiechert potentials for a moving point charge, Fields produced by a charge in uniform and accelerated motion, Radiation from an accelerated charge, Radiated power, Larmor's formula and its relativistic generalization, Thomson scattering of radiation, Thomson cross section. Bremsstrahlung, synchrotron radiation. Multipole expansion of electromagnetic fields, Energy and Angular momentum of multipole radiation fields.

(10 Lectures)

UNIT- IV

Scattering by free and bound electrons, Rayleigh Scattering, Frequency dependence of total cross section, Resonance fluorescence, State of polarization of scattered radiation, Coherence and incoherence in scattered light. Radiation damping, Radiative reaction force and its derivation, Difficulties with classical Abraham-Lorentz model, Integro-differential equation of motion, Pre-acceleration. Line breadth and Level shift of an oscillator. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Having attended this course, students will be able to feel the thrill of revolutionary motivation for special relativity obtained from electrodynamics. Students will be able to apply the acquired knowledge to conceptualize Poincare, Lorentz and other space time transformations (including space rotation and spacetime inversion) through world lines and light cones, and solve problems. They will learn and use tensor algebra and calculus as a language to calculate conserved and/or Lorentz invariant quantities and to express the covariance of physical laws. They would learn about causal and acausal potentials (to appreciate the role of time symmetry) and fields due to charges in relative motion. Further, students will be able to understand the nature of radiation from accelerated charges, and its interaction with matter in various scattering processes. Thus, they would also understand, and enquire in to, some of the exciting applications in radiative scattering at the present and future high energy particle colliders.

Reference Books:

1. Classical Electrodynamics: John David Jackson (Wiley India).
2. Introduction to Electrodynamics: David J. Griffiths (Prentice-Hall of India, New Delhi).
3. An Introduction to Relativity: J. V. Narlikar (Cambridge Univ Press).
4. Introducing Einstein’s Relativity: Ray D’Inverno (Clarendon Press, Oxford)
5. Electromagnetic Field Theory for Engineers and Physicists: G. Lehner (Spinger).
6. Modern Electrodynamics: A. Zangwill (Cambridge University Press)

M.Sc. (PHYSICS) SEMESTER- II

PHYCC-206

GENERAL EXPERIMENTS - LAB **(4 Credits)**

Course Objectives: The prime objective of this course is to understand the basic concepts of general physics/ electronics/nuclear physics through standard set of experiments. The continuous evaluation process allows each and every student to not only understand and perform the experiment but also suitably correlate them with the corresponding theory.

S.No.	Experiments
1.	Hall Effect
2.	E.S.R.
3.	Four Probe
4.	Forbidden Energy Gap
5.	Gm Counter
6.	β-Energy
7.	Klystron
8.	Phase Shifter

Course Outcomes: At the end of this laboratory course, each and every student is expected to understand the basic concepts of general Physics/electronics/nuclear physics through experiments. Recording data, plotting of graphs, extraction of relevant information from graphs and identifying the sources of experimental error is also a key outcome along with analyzing and presenting experimental findings through written laboratory reports.

Reference Books:

1. Electronic Devices and Circuit Theory: Robert L. Boylestad
2. Integrated electronics: Millman and Halkias
3. Solid State Physics: Streetman
4. Electronic Principles: Albert Malvino and David bates (Eighth edition)
5. Electronic Communication systems: Kennedy
6. Fundamentals of Molecular Spectroscopy by C.N. Banwell
7. Radiation Detection and Measurement: Glenn F. Knoll
8. Radiation Detection: W. H. Tait

M.Sc. (PHYSICS) SEMESTER- III

PHYVNC-201

ELEMENTS OF ATMOSPHERIC AND SPACE SCIENCE

Total Lectures 45 **(0 Credits)**

Course Objectives: This course will provide an elementary concept about the atmosphere and the Sun (solar activity) to PG students and enrich their understanding of the science in daily life.

UNIT- I

Lower atmosphere: Composition, constituents, dynamics; diurnal and seasonal variations of Temperature, Pressure and Humidity; Ozone hole and its impact on climate. **(10 Lectures)**

UNIT- II

Ionosphere and magnetosphere: structure and formation, Density profile of upper atmosphere. Storm – substorm phenomena. **(10 Lectures)**

UNIT- III

Structure of the Sun: Solar interior, solar atmosphere, photosphere, chromosphere, corona; Sunspots and their properties. **(10 Lectures)**

UNIT- IV

Solar cycle and solar activity: Solar Wind, Solar Flares, Coronal Mass Ejections (CMEs); heliosphere and solar magnetic field. Space Weather: causes and consequences. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester) **(5 Lectures)**

Course Outcomes: After gaining the elementary knowledge of Atmosphere and Space related concepts, student will impart his wisdom further to some major organizations like NARL & ISRO etc.

Reference Books:

1. Meteorology: Understanding the Atmosphere: Steven A. Ackerman and John A. Knox
2. An introduction to Meteorology: S. Petterssen, McGraw-Hill Book Company, USA

3. Element of Space Physics: R.P. Singhal, Prentice Hall of India, New Delhi
4. Astrophysics of the Sun: Harold Zirin, Cambridge University Press, Cambridge, U.K. 2.
5. Guide to the Sun: Kenneth J. H. Philips, Cambridge University Press, U.K.

M.Sc. (PHYSICS) SEMESTER- III

PHYCC-301

QUANTUM MECHANICS- II

Total Lectures 45 **(4 Credits)**

Course Objectives: The primary objective is to teach the students the concept of commutation relations of angular momentum and symmetry along with Relativistic Quantum mechanics. The important topic of non relativistic scattering is also dealt with.

UNIT- I

Angular Momentum: Commutation relations of angular momentum operators. Eigen values, eigenvectors. Ladder operators and their matrix representations. Spin angular momentum and Pauli matrices. Identical particles: Many-particle systems, Exchange degeneracy, symmetric and anti-symmetric wavefunctions. Pauli exclusion principle. Addition of angular momenta. Clebsch-Gordan coefficients. Wigner -Eckart theorem.

(10 Lectures)

UNIT- II

Symmetry in Quantum Mechanics- Symmetry transformation, Translation in space, Conservation of linear momentum, translation in time, Conservation of energy, Rotation in Space, Conservation of angular momentum, Space inversion, Time Reversal.

(10 Lectures)

UNIT- III

Relativistic Wave Equations – Klein-Gordon equation, Dirac equation. Properties of Dirac matrices, Plane wave solution of Dirac equation, spin and magnetic moment of the electron, non-relativistic reduction.

(10 Lectures)

UNIT- IV

Non-relativistic scattering theory, differential and total scattering cross section, Born approximation method with examples of scattering by Coulomb, Gaussian, Square well and Yukawa potentials. Partial wave analysis, optical theorem, phase shift, example of scattering by square well potential.

(10 Lectures)

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Students will learn the basic ideas of angular momentum and symmetry .Relativistic Quantum Mechanics will provide an exposure to how special relativity in quantum theory leads to intrinsic spin angular momentum as well as antiparticles approximations methods along with scattering theory shall presumably equip the student with sufficient knowledge to solve related problems.

Reference Books:

1. Principles of Quantum Mechanics: R Shanker
2. Quantum Mechanics (vol 1): Tannoudji
3. Quantum Mechanics: E Merzbacher
4. Quantum Mechanics; Concepts and applications: N Zettili
5. Introduction to Quantum Mechanics: Griffiths
6. Quantum Mechanics: Schiff
7. Quantum Mechanics :Liboff
8. Quantum Mechanics Theory and Applications: Ghatak and Loknathan

M. Sc. (PHYSICS) SEMESTER- III

PHYCC-302

NUCLEAR PHYSICS- II

Total Lectures 45 **(4 Credits)**

Course Objectives: The main objective of the course is to impart the basic knowledge of fundamental particles, fundamental interaction and the range and strength of these interactions with the concept of particle antiparticle or matter antimatter and their classifications, Standard model.

UNIT- I

Nuclear two-body problem, Simple theory of deuteron, Spin dependence and non-central feature of nuclear forces, Partial wave analysis, Low energy n-p scattering, Low energy p-p scattering, Existence of two nucleon bound system, Scattering length and effective range theory, Charge symmetry and charge independence of nuclear forces, Meson theory of nuclear forces.

(10 Lectures)

UNIT- II

Magic numbers and evidence of shell structure, Extreme single particle shell model, Predictions of spin, parity and electromagnetic moments, Nilsson Model (Qualitative), Collective model, Rotational and Vibrational Hamiltonian, Energy levels and band structure due to single particle; Vibrational and rotational behaviour of different nuclei.

(10 Lectures)

UNIT- III

Classification of elementary particles Exact conservation laws, Approximate conservation laws: Isospin and Isospin wave functions for pion-nucleon system, strangeness, parity, time reversal and charge conjugation, CP violation. **(10 Lectures)**

UNIT- IV

Eight fold way, Quarks, Quark-Quark interaction, SU(3) quark model, Magnetic dipole moment of baryons, Masses of hadrons. Basic ideas about the standard model. Mass generation.

(10 Lectures)

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: After completion of the course the student will be able to understand and appreciate the role of symmetries in physics. The knowledge of Nucleon-nucleon interactions will lead to better understanding of the nuclear force and nuclear structure.
Understanding of the Standard model of the particle physics will help in validating the theory with the experimental results. It will motivate students to look for new physics too (beyond the SM).

Reference Books:

1. Nuclear and Particle Physics: W. Burcham and M. Jobes.
2. Quarks and Leptons: Halzen and Martin, Jon Willey and Sons
3. Unitary symmetry and Elementary Particles: D.B.Lichtenberg.
4. Symmetry Principles in particle Physics: Emmerson.
5. Introduction to High Energy Physics: Donald H. Perkins, University of Oxford.
6. Nuclear Physics: S. N. Ghoshal, First edition, S. Chand Publication.
7. Nuclear & Particle Physics: An Introduction : B. Martin (Willey, 2006)
8. Introduction to Elementary Particles: D. Griffiths (Academic Press, 2nd Ed. 2008)

M.Sc. (PHYSICS) SEMESTER- III
PHYEL- 301 A
ELECTRONICS - I

Total Lectures 45 **(4 Credits)**

Course Objectives: To gain a deeper understanding of linear and digital electronic circuits, to be able to conceptualize, implement and actualize both linear and digital electronics circuits. The course will enable students to study the design and implementation of digital circuits and also the microprocessor architecture as a basis for computers.

UNIT- I

Linear Wave Shaping**:** High Pass and Low Pass RC Networks: Detailed Analysis; Response to Sinusoidal, Step, Pulse, Square wave, Exponential and Ramp Inputs; RC circuits applications; High pass RC circuit as a differentiator, Low Pass RC circuit as an Integrator; Criterion for good differentiation and integration. Laplace Transforms and their application to circuit elements.
(10 Lectures)

UNIT- II

Amplifiers: Difference Amplifiers; Broadband Amplifiers, Methods for achieving broad-banding ;Emitter Follower at High Frequencies; Operational Amplifiers and its Applications. **(10 Lectures)**

UNIT- III

Power Supplies: Electronically Regulated Power Supplies; Converters and Inverters; High and Low Voltage Supplies, Application of SCR as Regulator; SMPS; Elements of Digital Circuit Technology: Transistor as a Switch – Switching times: Definition and Derivation - Rise Time, Fall Time, Storage Time, Delay Time, Turn On Time, Turn Off Time Charge Control Analysis; Multi-vibrators: Astable, Monostable and Bistable; Schmitt Trigger. **(10 Lectures)**

UNIT- IV

Flip Flops: RS, RST, JK, T, D, JK M/S Flip flops, Race problem, Preset and Clear functions; Binary Codes: Gray, 8421, 2421. Arithmetic Circuits. Boolean Variables and Operators, Simplification of Boolean Expressions. Karnaugh Maps; Registers and counter: Shift registers, types of synchronous and asynchronous, ring counter modulus and UP/DOWN counters; D/A converter and A/D converter. Simultaneous and Counter method of A/D converter, Successive Approximation method. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: The course aims to develop a deep understanding of amplifier circuits. It will also serve as a foundation for understanding computer architecture. The student will be able to design and troubleshoot simple digital circuits.

Reference Books:

1. Integrated Electronics: Millman and Halkias.
2. Pulse Digital and switching waveforms: Millman & Taub
3. Digital Technology: WH Gothman
4. Digital Electronics: Principles and Practice- Virender Kumar
5. Digital Principles and Applications: Malvino & Leach
6. Digital Fundamentals: TL Floyd

M.Sc. (PHYSICS) SEMESTER-III

PHYEL-301 B

LASERS AND OPTO-ELECTRONICS – I

Total Lectures 45 **(4 Credits)**

Course Objectives: The primary objective is to introduce the physics of Laser systems, non linear optical phenomena, optical phase conjugation and Optical fibers.

UNIT- I

Laser theory, Light Amplification, threshold condition, Laser Rate Equations-two, three and four level systems, Laser power around threshold, optimum output coupling, Line Broadening Mechanisms–Natural, Collision and Doppler, Optical Resonators – Modes of a rectangular cavity and open planar resonator, Modes of a Confocal resonator system, General Spherical resonator, Higher order modes. **(10 Lectures)**

UNIT- II

Essential criterion to observe non linear optical effects. First experimental demonstration of non-linear phenomena, Classical theory of non-linear response in one dimension, Generalization to three dimensions, General properties of the polarizability tensor – Reality condition, Intrinsic symmetry, general form and frequency dependence, overall symmetry, Second harmonic generation and phase matching techniques, Basic idea of self-focusing. **(10 Lectures)**

UNIT- III

Non-linear coupling of three waves to produce sum and difference frequencies, Manley Rowe relations and their significance, Sum and difference frequency generation when both input frequencies are lasers, Parametric conversion and amplification, Basic idea of optical phase conjugation. **(10 Lectures)**

UNIT- IV

Optical fiber as a guiding medium, Total Internal reflection, Acceptance angle Numerical aperture, Types of fiber, Refractive index profiles, Concept of modes, Electromagnetic analysis of guided modes in symmetric step index planar wave guide and step index fiber, Concept of Normalized Frequency, V Parameter, Pulse dispersion in step index fibers. Concept of Dispersion shifted and Dispersion flattened Fibers, Fiber attenuation, Misalignment losses, Fiber material, Fiber fabrication, Splices and Connectors. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Students will learn to analyze any laser system and optical resonators. They can use their knowledge of mathematical physics taught in semester 1 viz. Hermite polynomials, Hermite
Gauss function etc. to understand modes in a resonator. Students' horizon will expand beyond linear aspects by knowing about various exotic phenomena occurring in non-linear optics. They can relate it with various advanced devices using second harmonic generation and optical phase conjugation. Students will also learn about optical fibers in detail and will be able to appreciate the current communication system existing globally.

Reference Books:

1. Optical Electronics: A. Ghatak and K. Thyagrajan (Cambridge University Press)
2. Lasers: Eberly
3. Principle of Lasers: Orazio Svelto, Springer
4. Lasers and non-linear optics: B B Laud, New Age International (P) Limited Publishers
5. Non-linear optics: Robert W Boyd, Elsevier
6. Optical Fiber Communication Principle and Practice: John M Senior, Pearson Education
7. Optical Communication Systems: John Gower, Prentice Hall of India
8. Fiber Optics Communication: Palais, University Press
9. Introduction to Optical Fibers and its Applications: Rajesh Shukla, Lap Lambert Academic Publishing

M.Sc. (PHYSICS) SEMESTER- III

PHYEL- 301 C

X-RAY CRYSTALLOGRAPHY-I

Total Lectures 45 **(4 Credits)**

Course Objectives: Main goal of the course is to gain knowledge to understand the x-ray scattering and dispersion phenomena and their theories. This course also provides the fundamental and advanced understanding of crystallography.

UNIT- I

Scattering of X-rays, Compton scattering and Thompson's theory scattering by a pair of electrons and electron cloud in an atom, Atomic structure factors. Scattering by diatomic and simple polyatomic molecules. **(10 Lectures)**

UNIT- II

Scattering by liquids and determination of atomic distribution in monatomic liquids, Zernicks Prins Formula, Derived charge distribution and a comparison with Hartee-Fock and Thomas Fermi models, Intensity of scattering from free electrons. Klein Nisima formula (no derivation), Comparison with experiments. Dispersion theory applied to x-rays, Anomalous dispersion, The forced, Damped oscillations of an electron and dielectric constant of the medium. **(10 Lectures)**

UNIT- III

Diffraction of x-rays by Crystals, Laue's and Bragg's equations for X-ray diffraction and their equivalency, Neutron and electron diffraction, relative merits and demerits of electron, neutron and X-ray diffraction. Various methods of X-ray diffraction; Collimation and recording of X-ray beam, Laue, Powder, Rotating/oscillating and moving film methods in details. Interpretation of diffraction pattern with the help of various tools, factors affecting X-ray intensities. **(10 Lectures)**

UNIT- IV

The phase problem and various methods of its solution, trial and error methods, optical method, Fourier and Patterson methods. Small angle X-ray scattering (SAXS) from crystalline and non-crystalline materials; General theory; scattering by a single particle, group of particles. Experimental consideration for construction of SAXS apparatus, method of interpretation and comparison of experimental SAXS results and its application to the study of metals, alloys, polymers, finally dispersed solid, large molecules etc. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Students will learn the principles of interaction of X-rays with matter. They will gain knowledge about x-ray scattering and dispersion of x-rays. They will understand the x-rays diffraction by crystals, electrons and neutrons, their merits and demerits. Students will also learn various methods of X-ray diffraction and would be able to interpret diffraction patterns with the help of various tools. Students would be able to understand experimental consideration for construction of SAXS apparatus, methods of interpretation and comparison of experimental SAXS results and its application to the study of metals, alloys, polymers.

Reference Books:

1. Crystal Structure Analysis, Principle and Practice (International Union of Crystallography Monographs on Crystallography 13), Blake, Clegg, Cole, Evans, Main, Parsons, Watkin, Editor William Clegg. ISBN: 9780199219469
2. X-Rays in Theory and Experiment: Arthur H. Compton and Samuel K. Allison
3. Elements of X-ray crystallography: Leonid V. Azároff

M.Sc. (PHYSICS) SEMESTER- III

PHYEL-302 A

ELECTRONICS - LAB A (4 CREDITS)

Course Objectives: To gain a hands on experience working with real time circuits, to translate theory into practice. And to design, implement and troubleshoot linear and digital electronics circuits.

S.No	Experiments
1.	Study of Digital Circuits
2.	Study of Emitter Follower
3.	Study of Difference Amplifier
4.	Study of Schmitt Trigger
5.	Study of Pam, Pwm, Ppm
6.	Study of Pcm Receiver and Transmitter
7.	Study of Op-amp Characteristics
8.	Study of Op-amp Applications
9.	Study of Analog To Digital Converters
10.	Study of Digital To Analog Converters
11.	Study of Multi-vibrators
12.	Study of 555 Timer
13.	Study of Alu Ic 74181
14.	Study of Microprocessor Ic 8085

Course Outcomes: At the end of the course the student shall be able to understand the working of most digital platforms irrespective of the stream and also why digitization is important in today's scenario.

Reference Books:

1. Modern Communication Systems: BP Lathi.
2. Communication Electronics: Roddy & Coolen
3. Television fundamentals: Dhake
4. Microprocessor, Architecture, Programming and Applications: RS Gaovkar
5. Fundamentals of Microprocessors and Microcomputers: B. Ram
6. Digital Fundamentals: TL Floyd

M.SC. (PHYSICS) SEMESTER- III

PHYEL-302 B

OPTO-ELECTRONICS - LAB B (4 Credits)

Course Objectives: This course will render skill on the experimental techniques related to lasers, optical fibers and fiber optic communication.

Any 7 to be performed in a semester.

S.No.	Experiments
1.	Study of Characteristics of Led and Pin Photo Detector
2.	Study of Frequency Response of Optical Receiver
3.	To Study Attenuation In Optical Fibers
4.	To Find Numerical Aperture of Optical Fibers
5.	Study of Noise in an Optical Receiver
6.	To Study Abbe's Theory of Image Formation and Spatial Filtering
7.	To Study Diffraction Pattern Using a Software Controlled Set-Up Self-Imaging
8.	Self-Imaging
9.	To Study Micro-bending Losses In An Optical Fiber
10.	Study of Pulse Amplitude Modulation And Time
11.	Study of Digital Data Communication
12.	Study of Nrz and its Detection
13.	Study of Rz and its Detection
14.	Study of Manchester Coding and its Detection
15.	Study of Ask Modulation and Demodulation

Course Outcomes: Students will learn to handle lasers, fibers, LEDs, PDs, optical source and power meter. They will learn to examine them. They will learn various aspects of fiber optic communication viz. end preparation, numerical aperture, bandwidth, joint and losses etc. They will learn optical alignment, laser parameters and properties, basics of optical data processing etc. Thus students will get insight and will be able to correlate with the theory studied.

Reference Books:

1. Laser Fundamentals: William T. Silfvast, Cambridge University Press
2. Optical Electronics: A. Ghatak and K. Thyagrajan , Cambridge University Press
3. Laser Physics: Joseph H Eberly and Peter W Miloni, Wiley
4. Principle of Lasers: Orazio Svelto, Springer
5. Optical Fiber Communication Principle and Practice: John M Senior, Pearson Education
6. Optical Communication Systems: John Gower, Prentice Hall of India
7. Fiber Optics Communication: Palais, University Press
8. Optical Fiber Communication: Gerd Keiser, McGraw Hill Education
9. Optical Electronics: A. Ghatak and K. Thyagrajan (Cambridge University Press)

M.SC. (PHYSICS) SEMESTER- III

PHYEL-302 C

X-RAYS - LAB C **(4 Credits)**

Course Objectives: The main aim of the course is to achieve detail knowledge about the various significant experimental techniques to determine the various parameters such as crystal structure, wavelengths and lattice parameters of the materials.

Experiments:

1. To take the powder photograph of copper (Cu) and tungsten (W) and index it. (12 hours)

2. To take the Laue photograph of KCl and KDP crystals and their indexing. (12 hours)

3. To take the 15° oscillation photograph of KCl and KDP crystal and hence index the reflection spot. (12 hours)

4. To determine the wavelength of K_α and K_β lines of Mo by means of Muller spectrograph. (12 hours)

Course Outcomes: Students learn the experimental technique to determine the exact crystal structure of the polycrystalline materials. They will obtain knowledge about the single crystal and its indexing. They will understand the indexing mechanism of the obtained oscillation photograph pattern of various crystals. Moreover, students will learn about the determination of the wavelength of different lines and differences between them.

Reference Books:

1. Elements of X-Ray Diffraction: B. D. Cullity and S. R. Stock
2. Crystallography for Solid State Physics: Ajit Ram Verma and Onkar Nath Srivastava
3. X-Ray Spectroscopy: B.K. Agarwal

M.Sc. (PHYSICS) SEMESTER- III

PHYIN-301

SUMMER INTERNSHIP

(4 Credits)

Course Objectives - To extend classroom knowledge to real-world experience.

Course Outcomes -Summer Internship will help students understand more about the atmosphere of the workplace, leadership structure, and team spirit, which can help them have more ease on board in their first career job than if they had no professional experience.

M.Sc. (PHYSICS) SEMESTER- III

PHYIER-301(A)

INTRODUCTION TO ELECTRONIC COMMUNICATION

Total Lectures 45 **(4 Credits)**

Course Objectives: To study electronic communication which is necessary to understand the impact of scientific solution in global economic, environmental, societal context and to have knowledge of contemporary issues in science and technology .

UNIT- I

Introduction to modern communication systems, Electromagnetic spectrum and allocations, bandwidth and information capacity. Time and frequency domains. Signal magnitudes and ranges, Decibel calculations, Noise and its effect. **(10 Lectures)**

UNIT- II

Need for modulation, Basics of amplitude modulation, transmitter functions, receiver techniques. Concept of frequency modulation, FM spectrum and bandwidth. Comparison of AM and FM. **(10 Lectures)**

UNIT- III

Digital information in communication, Sampling bandwidth and bit rates. Analog to digital and Digital to analog converter. Introduction to the internet and world wide web. **(10 Lectures)**

UNIT- IV

Fiber-Optic system characteristics, The optical fiber, brief introduction of Sources and detectors for fiber optic communication, Complete systems and networks, Fiber optic testing.

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Understanding of, signal representation in both time and frequency domain, Understanding of, basic analog communication techniques like modulation theory, Understanding of, system design for analog modulator and demodulator, random process and effect of noise.

Reference Books:

1. Electronic communications: Dennis Roddy and Jhon Coolen. Publisher-Pearson Education
2. Kennedy's Electronic communication systems: George Kennedy, Bernard Devis, SRM Prasanna; Publisher-Mc Graw Hill Education

M. Sc. (PHYSICS) SEMESTER- III

PHYIER-301(B)

THE DIGITAL AGE

Total Lectures 45 **(0 Credits)**

Course Objectives: The advent of the digital age has eased life to a large extent, at the same time it has brought with it a number of hitherto unforeseen problems. The topics enumerated here provide a basic understanding of trends in technology, its impact on common life and also its potential misuse. The idea is to raise the awareness of the common students especially from humanities to certain technical aspects of devices commonly used. Also they need to understand its potential misuse and how to prevent it. The course is of three credits. The student will become aware of and be better able to use the latest devices, techniques and applications pertaining to digitization.

UNIT- I

Digital vs Analog, the Binary world, Boolean choices and decision making, the art of algorithms.

(10 Lectures)

UNIT- II

Ethical hacking, cybersecurity, phishing, evolution of predictive analysis, dark data migration to the cloud, EDGE computing. **(10 Lectures)**

UNIT- III

What is SMART in smart devices? Heart sensors, pulse monitors, digitized medical equipment, Smart homes, The internet of things (IoT). **(10 Lectures)**

UNIT- IV

Quantum computing and Artificial Intelligence, Silicon Immortality, Virtual Reality, Simulation, Machine learning, Sensors, Application to medicine esp. Neuroscience. Will the internet save us from epidemics? Effect of Technology on environment. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: At the end of the course the student shall be able to understand the working of most digital platforms irrespective of the stream and also why digitization is important in today's scenario.

M. Sc. (PHYSICS) SEMESTER- IV

PHYCC-401

SOLID STATE PHYSICS- 1I

Total Lectures 45 **(4 Credits)**

Course Objectives: To Know about the role of Solid State Physics in important technological development.

UNIT- I

Dielectric and Ferroelectric Properties- Macroscopic and microscopic electric field, Lorentz relation, Clausius-Mossotti equation, Debye equation , Polarizability: Ionic Polarizability, Dipolar Polarizability, Electronic Polarizability and their frequency dependence, Classical theory of electronic polarizability. Dielectric constant and Dielectric dispersion, Structural phase transition, Soft modes, Antiferroelectricity, Ferroelectric domains, Piezoelectricity, Pyroelectricity.

(10 Lectures)

UNIT- II

Magnetic properties-Quantum theory of diamagnetism and para-magnetism, Susceptibility behavior of paramagnetic systems, super para-magnetism, Behavior of Fe and rare earth groups, Quenching of orbital magnetic moments, paramagnetic moment of metallic solids. Van Vleck para-magnetism, Heisenberg theory, Spin wave theory for ferromagnetic and antiferromagnetic systems, T3/2 law. Acoustic and optical magnons. Phase transformation in antiferromagnetic systems, Susceptibility behavior of ordered systems, Anisotropy Domain theory, Bloch wall, Coercivity and Hysteresis, Amorphous ferromagnets. **(10 Lectures)**

UNIT- III

Band Theory- Bloch theorem, Tight binding approximation, LCAO method and its application, derivation of dispersion relation, concepts of effective mass and holes ,Brillouin zones, reduced zone scheme, Shape of bands and their overlapping, behavior of ionic-covalent and metallic solids, Construction of Fermi-surfaces, Methods for the study of Fermi surfaces, Anomalous Skin Effect , Cyclotron resonance, Extremal orbits, Landau energy levels, Magnetic sub-bands, Landau diamagnetism, de Hass-van Alphen Effect . **(10 Lectures)**

UNIT- IV

Electronic and optical properties- The upper filled band and the conduction band in ionic crystals Excitons, Qualitative discussion of lattice defects and their influence on electronic levels, Colour centers, Luminescence, thallium activated alkali halides. General-Alloys, Substitutional solid solution ,Order disorder transformation, Phase diagrams, Elementary theory of order, Transition metal alloys and KONDO effects. Nanomaterials: Fullerene, Graphene and Carbon Nanotubes.

(10 Lectures)

UNIT- V

(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: The main outcome of this course is to learn about the properties of crystalline solids. The quantum and statistical mechanics concepts and formalism are used to understand the behavior condensed materials. The students will gain knowledge of basic theories of solid materials and ideas of describing the basic experimental measurements.

Reference Books:

1. Introduction to Solid State Physics: C. Kittel
2. Solid State Physics: N. W. Ashcroft and N. D. Mermin
3. Solid State Physics: A. J. Dekker
4. Solid State Physics: M.A. Wahab

M.Sc. (PHYSICS) SEMESTER- IV

PHYEL-401

MATHEMATICAL PHYSICS- II

Total Lectures 45 **(4 Credits)**

Course Objectives: The primary objective is to teach the students basic mathematical methods that will be used in many of the other courses in the M.Sc. syllabus

UNIT- I

Partial differential equations, Lagrange's linear equation, Method of multipliers Solutions of Laplace, Poisson, Diffusion and wave equations in cartesian, spherical and cylindrical co-ordinates Physical applications of the above topics. **(10 Lectures)**

UNIT- II

Inhomogeneous equations, Green's function for a free particle, Fourier series, Dirichlet's conditions, Even and odd functions, Parseval's identity for Fourier series Fourier integral, different forms of Fourier integrals, Parseval's identity for Fourier integrals Fourier sine, cosine and complex transforms Beta and Gamma functions, Different forms of Beta and Gamma functions and relation between them Physical applications of the above topics. **(10 Lectures)**

UNIT- III

Binary operation, Definitions of Group, Semi-Group and Abelian group, Multiplication table, Equivalence class, Conjugate elements and classes**.** Invariant subgroups, Permutation group, Cyclic group, Co-sets of a subgroup**.** Finite and infinite group, Period of the group. **(10Lectures)**

UNIT- IV

Similarity transformations, Representation Character of Trace of the group, Schur's Lemma and the Orthogonality theorem Examples of C2v, Regular representation, Symmetrized basis functions for irreducible representation Direct product of representation. Applications to simple vibrational problems. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: Students will learn the required Mathematical techniques that may have not been covered in the courses in B.Sc. CBCS programme and which will be useful in many other courses in M.Sc.

Reference Books:

1. Advanced Engineering Mathematics: Erwin Kreyszig
2. Applied Mathematics for Engineer & Physicists: Louis A. Pipes & Lawrence R Harvill
3. Mathematical Methods for Physicists: G. Arfken
4. Mathematical Physics: V. Balakrishnan
5. Mathematical Physics: B.D. Gupta
6. Mathematical Physics: B.S. Rajput
7. Elementary Ideas of Group Theory: A.W. Joshi
8. A Friendly Introduction to Group Theory: David Nash
9. Group Theory: W.R. Scott

M.Sc. (PHYSICS) SEMESTER- IV

PHYEL-402 A

ELECTRONICS- II

Total Lectures 45 **(4 Credits)**

Course Objectives: To gain a deeper understanding of the design and implementation of digital circuits and also the microprocessor architecture as a basis for computers.

UNIT- I

Amplitude and Frequency Modulation: Introduction, Amplitude Modulation; Spectrum of the modulated signal; Square law Modulator, Balanced Modulator, DSBSC, SSB and vestigial sideband modulation; Limitations of Amplitude Modulation; Analysis and frequency Spectrum; Generation and Detection of FM; Comparison of AM and FM; Pre-emphasis and De-emphasis, Reactance Modulator. Capture Effect. Varactor Modulator; FM Receiver, Foster Seely Discriminator. Ratio Detector. **(10 Lectures)**

UNIT- II

Television: Electronic image capture, Conventional Camera tubes & Modern Devices; Interlaced Scanning; Synchronization, Resolution; Composite Video Signal. Vestigial Sideband Modulation; Transmitter/Receiver- B/W TV & Colour TV, Receiver Block Diagram. Sync. Separator. Vertical and Horizontal deflection circuits; Modern Display Technology: Flat Panel Displays(LCD, Plasmas etc.) and their addressing techniques. Smart Windows. **(10 Lectures)**

UNIT- III

Digital Communication: Basics of Digital Communications, Advantages of Digital Communication, Typical communication system (02 Lectures) Mathematical Theory of Digital Communication: Classification of signals, unit impulse function, Sampling property of the unit impulse function, unit step function, Analysis and transmission of signals, expression of an aperiodic signal as a continuous sum of exponential functions, unit gate function, Fourier spectrum of the gate pulse, The 'mathematics' of modulation, Impulse train and its Fourier response, ideal and practical filters, Sampling Theorem, Nyquist rate and Nyquist interval, Signal reconstruction: The Interpolation Formula, The Interpolation Function, Practical difficulties in signal reconstruction, Aliasing, Pulse Code Modulation, Basic stages of Generation and Reception of PCM, Quantizing, Compandor, Encoder; Differential Pulse Code Modulation, Delta Modulation; Principles of Digital data transmission: Amplitude Shift Keying, Frequency Shift Keying. Phase Shift Keying. Differential Phase Shift Keying. Digital Multiplexing. **(10 Lectures)**

UNIT- IV

Memory Devices: Volatile and non volatile memories, magnetic memories, DRO, NDRO system Semiconductor memories RAM, ROM, EPROM Bus organization Arithmatic unit , Binary addition Half and Full subtractor; Intel Microprocessors: Historical Perspective. Organization of Microprocessor based system. 8085: Programming model. Registers, Accumulator, Flags, Program Counter, Stack Pointer. Pin configuration 8085 Instruction Set: Data Transfer Operation, Arithmetic Operations, Logic Operations, Branching Operations, One, Two and Three Byte Instructions, Opcode Format; Microprocessor 8086, its organization & instructions. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: The student learns to program a microprocessor. The student can design and troubleshoot simple AM/FM circuits.

Reference Books:

1. Modern Communication Systems: BP Lathi.
2. Communication Electronics: Roddy & Coolen
3. Television fundamentals: Dhake
4. Microprocessor, Architecture, Programming and Applications: RS Gaovkar
5. Fundamentals of Microprocessors and Microcomputers: B. Ram
6. Digital Fundamentals: TL Floyd

M.Sc. (PHYSICS) SEMESTER-IV

PHYEL-402 B

LASERS AND OPTO-ELECTRONICS – II

Total Lectures 45 **(4 Credits)**

Course Objectives: The objective here is to go deeper in laser physics and fiber-optic communication after the initial knowledge imparted in semester 2. Another objective is to introduce holographic techniques and applications and stellar interferometers.

UNIT- I

Losses in the cavity – quality factor, line width of the laser, Mode selection – Transverse and longitudinal, free spectral range and finesse of etalon, Q – Switching – Peak Power, Total Energy, Pulse duration, Techniques for Q Switching- Mechanical, electro-optic and acousto-optic, Mode locking in lasers – Theory, Techniques for mode locking – Acousto-optic and electro-optic Laser Systems –Nd: YAG, Nd: Glass, CO2 Laser, Excimer Laser, Ti-sapphire laser. Free Electron Lasers – Introduction, Single particle dynamics, wiggler, electron trajectory, FEL Gain, Spontaneous Emission, effect of input wave polarization on FEL gain. Properties of Lasers – Directionality, Coherence etc. **(10 Lectures)**

UNIT- II

Conventional versus holographic photography, Hologram of a point source, hologram of an extended object, Off-axis technique in the recording of holograms, Three dimensional holograms – Reflection holograms, Basic idea of holographic data storage, Holographic interferometry – double exposure, real time, time average holographic interferometry, Optical correlation. Fourier Transform holograms and their use in character recognition. Optical data processing (basic idea). Abbe's theory. Spatial filters – low pass, high pass, band pass filters. Fraunhofer Diffraction and the Fourier Transform – mathematical concept, Young's experiment. Michelson Stellar interferometer and its limitation. Hanbury Brown and Twiss interferometer. Classical and quantum coherence functions, first and second order coherence, coherent states. Discussion of Young's experiment in quantum mechanical terms. **(10 Lectures)**

UNIT- III

Quantization of Analog signal, A/D and D/A conversion, Bit Rate, Pulse Code Modulation, NRZ, RZ and Manchester Coding, Base Line Wander Effect, Advantages of Optical Communication, Eye pattern Technique. Time Division Multiplexing, Wave length Division Multiplexing, Multiplexers and De-Multiplexers, Direct Detection and Coherent Heterodyne Detection. Concept of Optical Frequency Division Multiplexing, NEP Heterodyne. Erbium Doped Fiber Amplifier, Fiber Bragg Grating, System Design, Power Budget, Band width Budget and Rise Time Budget Calculations. **(10 Lectures)**

UNIT- IV

Electromagnetic analysis of guided modes in symmetric step index planar waveguide, Basic idea of asymmetric planar waveguides, Basic idea of slab guide geometries: strip, raised strip, embedded strip, ridge, strip coated guides. Fabrication of Integrated optical Devices: Substrate, cleaning of the substrate, Methods used to produce wave guiding layers, Sputtering and Dipping, Ion migration. Beam and waveguide couplers: Transverse couplers, prism-coupler, Grating coupler, thin-film tapered coupler, wave guide-to-fiber couplers. Electro-optic Effects, Acousto-optic Effect, Raman-Nath acousto-optic modulator Bragg modulator, Acousto-optic deflectors, Acousto-optic spectrum analyzer. Fiber optic sensors: Phase and polarization fiber sensors, Intrinsic sensors, Extrinsic fiber sensors, Sagnac Effect, Gyroscope. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: The students will learn laser physics in detail including various (solid state, gas, free electron) lasers systems viz. pulsed lasers and femtosecond lasers. The students will learn about holographic techniques, various types of holograms, optical data processing, quantum coherence functions and stellar interferometers. Further , using their knowledge of optical fibers students will learn optical communication, required coding, bandwidth budget, waveguides and optical couplers. They will also learn about fabrication of integrated optical devices, various optic effects and various types of sensors using optical fibers.

Reference Books:

1. Laser Fundamentals: William T. Silfvast, Cambridge University Press
2. Optical Electronics: A. Ghatak and K. Thyagrajan , Cambridge University Press
3. Laser Physics: Joseph H Eberly and Peter W Miloni, Wiley
4. Principle of Lasers: Orazio Svelto, Springer
5. Basics of Holography: P. Hariharan, Cambridge University Press
6. Introduction to Modern Digital Holography: TC Poon and JP Liu, Cambridge University Press
7. Optical Fiber Communication Principle and Practice: John M Senior, Pearson Education
8. Optical Communication Systems: John Gower, Prentice Hall of India
9. Fiber Optics Communication: Palais, University Press

M.Sc. (PHYSICS) SEMESTER- IV

PHYEL-402 C

X-RAYS: EMISSION AND ABSORPTION SPECTROSCOPY

Total Lectures 45 **(4 Credits)**

Course Objectives: Main goal of the course is to gain knowledge to understand the x-ray emission and absorption processes and their theories.

UNIT- I

X-ray emission from thin and thick targets, Theories of continuous X-ray spectra: Sommerfeld's theory for the spectral distribution, frequency spectrum of continuous X-ray Experimental spectral and spatial distribution, shortcomings of classical theory, Kramers quantum theory, X-ray emission spectra, X-ray energy level diagram, Diagram and forbidden lines in X-ray spectra. **(10 Lectures)**

UNIT- II

X-ray emission: multiple transitions, Selection rules, Relative intensities of emission lines in a multiplet, Spin and Screening doublets, screening parameters and their determination, recent advances in methods of calculation of screening parameters. X-ray satellites and their origin, parent line and its determination for satellites, Wetzel-Druyvesteyn theory of high energy satellites, hyper-satellites, theories for low energy satellites, Radiative transitions, Auger effect and its consequences in X-ray spectra. **(10 Lectures)**

UNIT- III

X-ray absorption, Absorption coefficients, Characteristic absorption limits and associated fine structure. Absorption jump ratios, Theory of absorption curve shape, Nature of the main absorption edge and the white line, X-ray absorption near edge structure, X-ray absorption main edge structure. **(10 Lectures)**

UNIT- IV

Introduction of Extended X-ray absorption fine structure, Long Range Order and Short Range Order theories of X-ray absorption fine structure, Kronig theory of extended X-ray absorption fine structure, modifications of Kronig theory, Single and double potential model of Lytle, Soft X-ray absorption Spectra: Recording and interpretation. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: The Students learn the principles of interaction of X-rays with matter. They will gain knowledge about x-ray emission from thick and thin targets and comprehensive feature x-ray emission theories. They will also understand the x-rays absorption, X-ray absorption near edge structure, X-ray absorption main edge structure and Extended X-ray absorption fine structure and their broad applications to understand the materials characteristics.

Reference Books:

1. X-Rays Absorption and X-Ray Emission Spectroscopy: J.A.v.Bokhoven & C.Lamberti
2. Advances in X-Ray Spectroscopy: C. Bonnelle
3. X-ray absorption spectroscopy (principles, applications, techniques of EXAFS, SEXAFS and XANES), edited by D.C. Konnigsberger and R. Prins, John Wiley and Sons, NY (1988)
4. X-Ray Spectroscopy: B.K. Agarwal

M.SC. (PHYSICS) SEMESTER- IV

PHYMT-401

MASTER THESIS **(8 Credits)**

Course Objectives: The master thesis project is intended to give an essence of research work.

Course Outcomes: Exposure to research within one of the research areas represented at the Department of Physics, through supervised master thesis project.

M.Sc. (PHYSICS) SEMESTER- IV

PHYIRA-401(A)

` **LASERS, OPTICAL FIBERS AND SENSORS**

Total Lectures 45 **(4 Credits)**

Course Objectives: Opting this course will give the students an opportunity to know and understand applications of fiber optics and laser technology. Students will be able to appreciate the importance of laser, fiber optical methods and sensors in all spheres of life i.e. various communication requirements, medical, travel etc.

UNIT- I

MASERS, Concept of Population Inversion, Laser Pumping, Resonators, Ruby laser, Helium-Neon laser, Semiconductor lasers, Liquid laser, Dye laser and Chemical laser, Properties of lasers, Lasers in Chemistry, Communication by Laser, Laser in Atmospheric Optics, Laser in Astronomy, Laser in Biology, Laser in Medicine, Laser in Industry. **(10 Lectures)**

UNIT- II

Demands of Information Age, The promise of Optical information processing, Evolution of Fiber Optics, Optical fiber Communication System, Block diagram of Optical fiber Communication System, Light propagation through medium, Total internal reflection, Numerical Aperture, Acceptance Angle. **(10 Lectures)**

UNIT- III

The optical fiber, Structure and types of fiber, Single mode fiber, Multimode Fiber, Step-index fiber, Graded-index fiber, Attenuation loss, Fiber materials, Fabrication of Optical fibers, Mechanical Misalignment, Fiber joints and Couples, Fiber Splicing, Demonstration of fiber optic communication. **(10 Lectures)**

UNIT- IV

Optical Sensors, Advantages of optical Sensors, Properties of Sensors, Sensors types, Biomedical Sensors, Chemical Sensors, Electrical and Magnetic Sensors, Rotation Sensors, Fiber-Optic Gyroscope, Sensors for structural health monitoring, Miscellaneous Sensors. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: The students will understand the basic characteristics of laser along with knowing various types of lasers and their application. They will also gain the knowledge of basic concepts of optical communication and of different types of optical fibers thereby getting enabled to appreciate the huge advantage of such systems. Students would be able to know about various types of fiber optic sensors and their use in the areas of security, safety, medical and space ventures. Finally, students may emerge with an idea for new sensor or a new application of the existing ones.

Reference Books:

1. Optical Fiber Communication Principle and Practice: John M Senior, Pearson Education.
2. Optical Communication System: John Gower, Prentice Hall of India
3. Fiber Optics Communication: Palais, University Press
4. Introduction to Optical Fibers and its Applications: Rajesh Shukla LAP LAMBERT Academic Publishing
5. Nonlinear Fiber Optics: G.P. Agarwal, Academic Press, San Diego California.
6. Laser: Eberly
7. Principles of Laser: Orazio Svelto, Springer
8. Introduction to Optics: Anchal Srivastava etc, New Age International Publishers, New Delhi
9. Laser, theory and Applications: K. Thyagarajan

M. Sc. (PHYSICS) SEMESTER- IV

PHYIRA-401(B)

SPECTROSCOPIC TECHNIQUES AND APPLICATIONS

Total Lectures 45 **(4 Credits)**

Course Objectives: This course is designed to deliver the understanding of the spectroscopic diagnostic techniques which are widely applicable in physics, chemistry, biology, and medicine, and its contributions to the solutions of technical and environmental problems are remarkable.

UNIT- I

Overview of CW and pulsed lasers, Generation of short laser pulses, Generation of femtosecond pulses, Reaching the attosecond range, Time-resolved laser Spectroscopy, Pump-and-Probe Spectroscopy of Collisional Relaxation in Liquids, Electronic Relaxation in Semiconductors, Femtosecond Transition State Dynamics, Real-Time Observations of Molecular Vibrations, Attosecond Spectroscopy of Atomic Inner Shell Processes. **(10 Lectures)**

UNIT- II

Basics of fluorescence excitation spectroscopy, ionization spectroscopy and multi-photon spectroscopy, laser-induced fluorescence (LIF), Determination of Population Distributions by LIF Basics of Laser Raman Spectroscopy, Linear and Nonlinear Raman Spectroscopy, Resonance Raman Effect, Surface-Enhanced Raman Scattering, Time-Resolved Raman Spectroscopy.

(10 Lectures)

UNIT- III

Laser Spectroscopy of Collision Processes, Collision Cross Sections of Excited Atoms and Molecules, Measurement of Collision-Induced Transitions in the Electronic Ground State of Molecules. Time-Resolved Infrared Fluorescence Detection, Time-Resolved Absorption, Collisions Involving Molecules in High Vibrational States, Optical Cooling of Molecules, Optical Trapping of Atoms, Applications of Cooled Atoms and Molecules. **(10 Lectures)**

UNIT- IV

Single-Molecule Detection, Laser-Induced Chemical Reactions, Coherent Control of Chemical Reactions, Laser Femtosecond Chemistry, Spectroscopy of Combustion Processes, Laser-Induced Breakdown Spectroscopy (LIBS), Energy Transfer in DNA Complexes, Time-Resolved Measurements of Biological Processes, Applications of Raman Spectroscopy in Medicine, Laser Lithotripsy, Atmospheric Measurements with LIDAR, Spectroscopic Detection of Water Pollution. **(10 Lectures)**

UNIT- V
(OPEN)

(Content to be announced at the beginning of the semester.) **(5 Lectures)**

Course Outcomes: On completion the course, students will have thorough understanding of the different spectroscopic techniques, interaction of light with matter on a microscopic scale and importance of different techniques in investigating specific problems.

Reference Books:

1. Experimental Techniques: Wolfgang Demtröder*;* Laser Spectroscopy Vol. 2: (Springer)
2. Laser Physics: Peter W. Milonni, Joseph H. Eberly; (Wiley)