Department of Physics

University of Lucknow

Syllabus for

Master of Science in Physics (Applicable From Session 2025-26 Onwards)

(Under National Education Policy 2020)

As per Ordinance 2024

To be effective from 2025-26

Offered Programmes:

- **M.Sc. Physics (2-Year Programme)**
- **M.Sc. Physics (1-Year Programme)**

University of Lucknow
Master of Physics Programme Regulations 2024

1. **Applicability**

These regulations shall apply to the Master in Physics Programme from the session 2025-26.

2. Minimum Eligibility for admission

As per university rules.

3. Programme Objectives

- To provide a robust theoretical and experimental foundation in Physics.
- To offer flexibility for specialization in various fields of Physics through elective courses.
- To enhance problem-solving, computational, and research skills.
- To develop interdisciplinary knowledge that integrates physics with other fields like electronics, computational physics, material sciences, energy and environmental physics, etc.
- To prepare students for careers in academia, research, industry, and entrepreneurship.

4. Programme Structure:

The M.Sc. Physics Programmes have been developed in alignment with the **National Education Policy (NEP) 2020**, emphasizing academic flexibility, interdisciplinary learning, research opportunities, and holistic development. These Programmes are designed to provide in-depth knowledge of fundamental and advanced topics in Physics, while also fostering innovation, critical thinking, and scientific inquiry.

5. Programme Outcomes

The Master of Science degree in Physics aims to provide students with the ability to study and develop theoretical understanding of the physical systems along with experimental skills to nurture innovation. The Programme also helps in

- Enhancing problem-solving and analytical skills to help students develop resilience and professional perspectives.
- Acquire discipline-specific expertise, such as self-directed scientific literature analysis, and use it to advance their research career.

6. Specific Programme Outcomes

Both M.Sc. Physics (2-Year Programme) and M.Sc. Physics (1-Year Programme) Programme focuses on advanced physics topics but differs in terms of depth and length of study. The 1-year MSc is typically more focused on specialized knowledge and research, while the 2-year MSc offers a more comprehensive and holistic Physics education with more time for exploration, research, and skill development. The Master of Science Programme in Physics imparts students with:

- Understanding of basic physics ideas allows one to comprehend and enjoy a wide range of phenomena occurring in the universe, both at the micro and macroscopic levels, in both non-relativistic and relativistic realms.
- Participation in a supervised Master's dissertation project in one of the Department of Physics' study areas.
- Advanced analytical abilities in Physics are required for a variety of jobs in education, research, and industry.
- Demonstrated competency in core Physics areas aligned with international norms, contributing to India's goal of becoming Atmanirbhar Bharat.

Proposed Course Code Preparation style

Position from	First, Second, and Third	Fourth	Fifth & Sixth	Seventh	Eighth & Ninth	Tenth (optional)
Code	Department Code	PG Programme length (in years)	Subject Category Core/ Elective/ Value Added/ Interdepartmental/ Master's Thesis/Internship	Level of Course	Course Specific Code Number	Elective options (if any)
left→ right	PHY	1/2	CC/EL/VC /IE/MT/IN	5/6	Odd semester: 01, 03, 05...... Even semester: 02, 04, 06,....	a/b/c

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PG 2 Year Programme Course Structure

The proposed structure of the M.Sc. in Physics- 2 year PG Programme – (under NEP 2020) to be effective from session 2025-26 onwards at the University of Lucknow would be as follows:

Year	Semester	Course Code	Course Type	Credit	Total
1	**Semester – I**	PHY2CC501	Mathematical Physics	4	20
		PHY2CC503	Electro Magnetic Theory	4	
		PHY2CC505	Solid State Physics	4	
		PHY2CC507	Classical Mechanics	2	
		PHY2CC509	Practical	4	
		PHY2VC511	Valued Added Course (Intradepartmental) 511a Laser, Optical fibers and Sensors	2	
	Semester - II	PHY2CC502	Quantum Mechanics	4	20
		PHY2CC504	Nuclear Physics	4	
		PHY2CC506	Classical Electrodynamics	4	
		PHY2CC508	Practical	4	
		PHY2CC510	Statistical Mechanics	2	
		PHY2IE512	Interdepartmental Course 512a/512b Introduction to Electronic Communication/Elements of Space Physics	2	
2	**Semester - III**	PHY2CC601	Advanced Quantum Mechanics	4	20
		PHY2CC603	Advanced Nuclear Physics	4	
		PHY2EL605	Elective Course 605a/605b/605c Electronics-I/Laser & Opto-electronics-I /X-rays-I	4	
		PHY2EL607	Elective Course 607a/607b/607c/ Practical Electronics/Laser & Opto-electronics/X-rays	4	
		PHY2EL609	Elective Course 609a/609b Innovations in Physics/ Physical Structure of the Universe	2	
		PHY2IN611	Internship Field Work	2	
	Semester – IV	PHY2CC602	Advanced Solid State Physics	4	20
		PHY2EL604	Elective Course 604a/604b Advanced Mathematical Physics/ Spectroscopic Techniques and Applications	4	
		PHY2EL606	Elective Course 606a/606b/606c Electronics-II/Laser & Opto-electronics-II/ X-rays-II	4	
		PHY2MT608	Master Thesis Dissertation	8	
			Total Credits		80

PG 1 Year Programme Course Structure

The proposed structure of the M.Sc. in Physics- 1 year PG Programme – (under NEP 2020) to be effective from session 2025-26 onwards at the University of Lucknow would be as follows:

Year	Semester	Course Code	Course Type	Credits	Total
1	**Semester - I**	PHY1CC501	Mathematical Physics	4	20
		PHY1CC505	Solid State Physics	4	
		PHY1CC513	Nuclear Physics	4	
		PHY1EL605	Elective Course 605a/605b/605c Electronics-I/Laser & Opto-electronics-I /X-rays-I	4	
		PHY1EL613	Elective Course 613a/613b/613c Practical Electronics-I/Laser & Opto-electronics-I /X-rays-I	2	
		PHY1VC511	Valued Added Course (Intradepartmental) 511a Laser, Optical Fibers and Sensors 511b Introduction to Skywatching	2	
	Semester- II	PHY1CC602	Advanced Solid State Physics	4	20
		PHY1CC612	Advanced Quantum Mechanics	4	
		PHY1CC614	Advanced Nuclear Physics	4	
		PHY1EL606	Elective Course 606a/606b/606c Electronics-II/Laser & Opto-electronics- II/ X-rays-II	4	
		PHY1EL610	Elective Course 610a/610b/610c Practical Electronics-II/Laser & Opto-electronics-II /X-rays-II	2	
		PHY1IE512	Interdepartmental Course 512a/512b Introduction to Electronic Communication/ Elements of Space Physics	2	
			Total Credits		40

Detailed Course Outline
for
2 Year PG Programme
(M.Sc. in Physics)

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER-I

PHY2CC501
Mathematical Physics

Total Lectures: 60 **(4 Credits)**

Course Objectives:

The primary objectives of this course aim at acquiring the stimulating knowledge of the Mathematical Physics and their unification in creating collective study of molecules of materials, in an interesting way. Students must understand the concepts of Mathematics formulate and solve field equations and handle various problems of Physics and Technology.

UNIT – 1 **(15 Lectures)**

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.

UNIT – 2 **(15 Lectures)**

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

UNIT – 3 **(15 Lectures)**

Ordinary point and singularities of a linear differential equation **,** Power series, solution of second order differential equations (Bessel, Legendre, Laguerre and Hermit equations)**,** Orthonormality, Rodrigues' formula and other properties of Legendre, Bessel and Laguerre functions and polynomials

UNIT – 4 **(15 Lectures)**

Interpolation formula for finite difference with equal and unequal intervals, Errors and accuracy tests in numerical analysis, the iterative algorithms for solving equations and finding roots, Discrete and Fast Fourier Transform.

Course Outcomes:

After attending this course, students would be able to apply knowledge of mathematical 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 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. Advance Engineering Mathematics: Erwin Kreyszig.
2. Mathematical method for Physics and Engineering: Riley.
3. Mathematical method for Physicists: George B. Arfkine.
4. Method of Mathematical Physics: Jeffreys.
5. Mathematical method for physical sciences: Mary L.Boas.
6. Applied Mathematics for Engineer and Physicist: Louis A. Pipes.
7. Mathematical methods for physics: G Arfken.
8. Mathematical Physics: V.Balakrishnam.
9. Mathematical Physics: B.S.Rajput.

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- I
PHY2CC503
ELECTROMAGNETIC THEORY

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT – II **(15 Lectures)**

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.

UNIT – III **(15 Lectures)**

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; Dispersion in Dielectrics and Conductors, Normal and Anomalous Dispersion, Kramer Kronig Relations.

UNIT – IV **(15 Lectures)**

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

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 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. Edminister (Tata McGraw Hill).
4. Electricity and Magnetism: E.M. Purcell (Berkeley Physics Course, McGraw-Hill, Vol II).
5. Foundations of Electromagnetic Theory: J. R. Reitz, F. J. Milford and R. W. Christy (Pearson).

M.Sc. (PHYSICS) 2-Year PG Programme - SEMESTER- I
PHY2CC505
SOLID STATE PHYSICS

Total Lectures 60 **(4 Credits)**
Course Objectives: Knowledge of the role of Solid State Physics in important technological development.

UNIT- I **(15 Lectures)**
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**.**

UNIT- II **(15 Lectures)**
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.

UNIT- III **(15 Lectures)**
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.

UNIT- IV **(15 Lectures)**
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 Tc super-conductors. Dislocation in Solids: Dislocations, Edge and screw dislocations, Burger vectors, Dislocation stress and strain, Fields of dislocations, Dislocation multiplication.

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) 2-Year PG Programme -SEMESTER- I
PHY2CC507
CLASSICAL MECHANICS

Total Lectures 30 **(2 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 **(7 Lectures)**

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.

UNIT- II **(8 Lectures)**

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.

UNIT- III **(7 Lectures)**

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.

UNIT- IV **(8 Lectures)**

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.

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) 2-Year PG Programme SEMESTER- I
PHY2CC509
PRACTICAL
(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 and H.T. Flint.
2. Fundamentals of Optics: Francis Jenkins and 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) 2-Year PG Programme -SEMESTER-I
PHY2VC511a
Laser, Optical fibers and Sensors

Total Lectures: 30 **2 Credits**

Course Objectives:

The primary objectives of this course aim at acquiring the stimulating knowledge of fiber optics and laser technology. Students must understand the importance of laser, fiber optical methods and sensors in all spheres of life i.e. various communication requirements, medical, travel etc.

UNIT – I **(10 Lectures)**

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, Laser in THz generation.

UNIT – II **(8 Lectures)**

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.

UNIT – III **(6 Lectures)**

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.

UNIT – IV **(6 Lectures)**

Optical Sensors, Advantages of optical Sensors, Properties of Sensors, Classification of Sensors: first, second and third generation sensors, and applications of fiber sensors.

Course Outcomes:

After attending this course, 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. Principles of Laser: Orazio Svelto (Springer).
7. Introduction to Optics: Anchal Srivastava (New Age International Publishers, New Delhi).
8. Laser, Theory and Applications: K. Thyagarajan (Springer Berlin Heidelberg).

M.Sc. (PHYSICS) 2-Year PG Programme- SEMESTER- II
PHY2CC502
QUANTUM MECHANICS

Total Lectures: 60 **4 Credits**

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

UNIT- I **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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 L2 and Lz, Spherical harmonics.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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 (Springer, Third edition, 2008).
6. Modern Quantum Mechanics: J.J. Sakurai (Addison-Wesley, 1993).
7. Quantum Mechanics: Eugen Merzbacher (Wiley, Third edition, 1997).

M.Sc. (PHYSICS) 2-Year PG Programme- SEMESTER- II
PHY2CC504
NUCLEAR PHYSICS

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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) 2-Year PG Programme -SEMESTER-II
PHY2CC506
CLASSICAL ELECTRODYNAMICS

Total Lectures: 60 **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 theory relativity 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 **(15 Lectures)**

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.

UNIT – II **(15 Lectures)**

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.

UNIT – III **(15 Lectures)**

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.

UNIT – IV **(15 Lectures)**

Scattering by free and bound electrons, Rayleigh Scattering, Frequency dependence of total cross section, Resonance fluorescence, State of polarization of scattered radiation. 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.

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) 2-Year PG Programme -SEMESTER- II
PHY2CC508

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: C.N. Banwell.
7. Radiation Detection and Measurement: Glenn F. Knoll.
8. Radiation Detection: W. H. Tait.

M.Sc. (PHYSICS) SEMESTER- II
PHY2CC510
Statistical Mechanics

Total Lectures 30 **(2 Credits)**

Course Objectives: This course develops concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, microcanonical, canonical and grant canonical ensembles; the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases; selected topics from low temperature physics and electrical and thermal properties of matter are discussed.

Unit –I **(8 Lectures)**

Macrostates and Microstates, Phase Space and Quantum states, Ludwig Boltzmann relation and Entropy, Condition for statistical equilibrium, Postulate of equal a prior probability, Ergodic hypothesis, chemical potential, Ensembles.

Unit –I **(7 Lectures)**

Partition Function, Partition function for microcanonical, canonical and grand canonical ensembles. Partition function for Magnetic substance. Thermodynamic Functions of an Ideal monoatomic gas by Partition function, Gibbs Paradox, Sackur Tetrode equation.

Unit –III **(8 Lectures)**

Maxwell-Boltzmann distribution law, Bose-Einstein Distribution law, Density of states for relativistic and non-relativistic particles, Degeneracy of Boson gas, Derivation of energy, pressure and specific heat of Boson gas. Bose-Einstein condensation, Properties of liquid Helium II, Laszlo Tisza two-fluid model.

Unit –IV **(7 Lectures)**

Fermi-Dirac Distribution Law, Degeneracy of Fermi gas, Energy and pressure of Fermi gas at absolute zero, Fermi energy, Fermi temperature, Heat capacity of electron gas, White Dwarf Stars, Chandrasekhar Mass Limit.

Course Outcomes: Students can apply statistical mechanics to calculate macroscopic properties from microscopic models. They can also apply statistical physics methods to solve problems in physical systems.

Reference Books:

1. An Introduction to Thermodynamics and Statistical Mechanics: Keith Stowe (Cambridge University Press, Second Edition).
2. Statistical Mechanics: R.K. Patharia, Paul D. Beale (Elsevier Ltd).
3. Thermodynamics and Statistical Mechanics: Richard Fitzpatrick.

4. Introductory Statistical Mechanics: Sanchez and Bowley (Oxford, Second edition).
5. Fundamentals of Statistical and Thermal Physics: F. Reif (McGraw-Hill, New York NY, 1965).
6. Thermal Physics: S.C. Garg, R.M. Bansal & C.K. Ghosh (Tata McGraw-Hill Education).

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- II
PHY2IE512a
INTRODUCTION TO ELECTRONIC COMMUNICATION

Total Lectures 30 **(2 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 **(8 Lectures)**

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.

UNIT- II **(7 Lectures)**

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

UNIT- III **(8 Lectures)**

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.

UNIT- IV **(7 Lectures)**

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

Course Outcomes: Understanding of, signal representation in both time and frequency domains, 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 (Pearson Education).
2. Kennedy's Electronic communication systems: George Kennedy, Bernard Devis, SRM Prasanna (Mc Graw Hill Education).

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- II
PHY2IE512b
ELEMENTS OF SPACE PHYSICS

Total Lectures: 30 **2 Credits**

Course Objectives: This course provides an in-depth understanding of the Sun, solar phenomena, and their interaction with the Earth. It equips students with knowledge about solar activity and its effects on space weather and terrestrial systems.

UNIT - I
Physical properties of the Sun: Solar size and mass, solar rotation, solar material, Sun`s core, photosphere, chromosphere, corona, solar magnetic field, solar wind and characteristics.

UNIT - II
Solar Activity and Variability: Solar magnetic activity, sunspots and their properties, solar magnetic fields, and differential rotation; solar cycle and its phases, solar dynamo theory; Periodicities and long-term variability of solar activity.

UNIT - III
Solar Transients: Solar flares and their classification, coronal mass ejections (CMEs); prominences, faculae, corpuscular clouds interaction with planetary systems, and formation of the heliosphere.

UNIT - IV
Solar-Earth Interaction and Space Weather: Solar storms, impact of solar activity on the ionosphere, magnetosphere and atmosphere, geomagnetic storms and substorms; aurora formation and dynamics; Space weather: causes and consequences, space climate.

Course Outcomes: Upon completing this course, students will:
1. Gain detailed knowledge of the Sun, its structure, and activity.
2. Understand the interaction between solar activity and the Earth's environment.
3. Develop skills to analyze space weather phenomena and their impact on technology.

Reference Books
1. The Sun: A Laboratory for Astrophysics by J. T. Schmelz.
2. Introduction to Space Weather by Mark Moldwin
3. Elementary Space Physics by R. P. Singhal
4. Solar Activity and Earth`s Climate by Rasmus E. Benestad

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- III
PHY2CC601
ADVANCED QUANTUM MECHANICS

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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: Tannoudji (vol 1).
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) 2-Year PG Programme- SEMESTER- III
PHY2CC603
ADVANCED NUCLEAR PHYSICS

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

Basic interactions and their mediating quanta, Types of particles and their families, Concept of Feynman diagrams and their applications, Eightfold 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.

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 a better understanding of the nuclear force and nuclear structure. Understanding of the Standard model of 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 (S. Chand Publication, First edition).
7. Nuclear & Particle Physics: An Introduction: B. Martin (Willey, 2006).
8. Introduction to Elementary Particles: D. Griffiths (Academic Press, Second edition, 2008).

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- III
PHY2EL605a
ELECTRONICS - I

Total Lectures 60 **(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 **(15 Lectures)**

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. The Transistor Hybrid Pi Model. Amplifiers: Difference Amplifiers; Broadband Amplifiers, Methods for achieving Broad-banding; Emitter Follower at High Frequencies. Operational Amplifiers and its Applications.

UNIT- II **(15 Lectures)**

Nanoelectronics: Fractional Quantum Hall Effect, Quantum Interference Transistor, Artificial Atoms, Coulomb Blockade, Single Electron Transistor, Quantum Dots, Spintronics. High Electron Mobility Transistor. Mesoscopic Physics, MODFET.

Quantum AI: Qubits, Multiple Qubits, Swap operation, the distinction between Classical and Quantum Computation, Quantum Teleportation, Actualizing Quantum Computers: some examples, Artificial Intelligence: Definition, Actualization, Applications, why Quantum AI?.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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) 2-Year PG Programme -SEMESTER-III
PHY2EL605b
LASERS AND OPTO-ELECTRONICS – I

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

Essential Criterion to Observe Nonlinear Optical Effects. First Experimental Demonstration of Nonlinear 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.

UNIT- III **(15 Lectures)**

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, Basic Idea of Multiphoton Processes.

UNIT- IV **(15 Lectures)**

Ray Propagation in Step-Index Fibers, Ray Propagation in Graded-Index Fibers, Concept of Normalized Frequency, V-Parameter, Pulse Dispersion in Step Index Fibers, Intersymbol Interference, Material Dispersion, Waveguide Dispersion, Concept of Dispersion shifted Fibers and Dispersion Flattened Fibers, Optical Fiber material, Fabrication of Optical Fibers, Fiber Connectors and Splices.

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) 2-Year PG Programme -SEMESTER- III
PHY2EL605c
X-rays-I (X-RAY CRYSTALLOGRAPHY)

Total Lectures: 60 **(4 Credits)**

Course Objectives: The primary objectives of this course are to gain knowledge to understand the basics of x-ray scattering and dispersion phenomena and their theories. This course also provides the fundamental and advanced understanding of X-crystallography using various methods.

UNIT – I **(15 Lectures)**

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. Dispersion theory applied to x-rays, Anomalous dispersion, The forced, Damped oscillations of an electron and dielectric constant of the medium.

UNIT – II **(15 Lectures)**

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.

UNIT – III **(15 Lectures)**

Sample preparation for phase identification and quantitative analysis, assigning hkl and cell parameters for refinement, Profile fitting using Le Bail and Pawley method, The phase problem and various methods of its solution, trial and error methods, optical method, Fourier and Patterson methods.

UNIT – IV **(15 Lectures)**

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.

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-ray 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: Principles and Practice: William Clegg, Alexander J Blake, Jacqueline M Cole, John S O Evans, Peter Main, Simon Parsons, David J Watkin, (Oxford University Press, Second edition, 2009).
2. X-rays in theory and experiment: Arthur H. Compton and Samuel K. Allison (Princeton, N.J., Van Nostrand, 1963).
3. Elements of X-ray crystallography: Leonid V Azároff, New York (McGraw-Hill, 1968).
4. Principle and Applications of Powder Diffraction: Abhram Clearfield, Joseph Reibenspies and Nattanai Bhuvanesh (Willy Publication, 2009).

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- III
PHY2EL607a

ELECTRONICS - LAB (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, Programmeming and Applications: RS Gaovkar.
5. Fundamentals of Microprocessors and Microcomputers: B. Ram.
6. Digital Fundamentals: TL Floyd.

M.SC. (PHYSICS) 2-YEAR PG PROGRAMME -SEMESTER- III
PHY2EL607b

LASERS & OPTO-ELECTRONICS - LAB (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-
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) 2-YEAR PG PROGRAMME -SEMESTER- III
PHY2EL607c

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

Course Objectives: The main objectives of this course is to acquire detail knowledge about quantitative and qualitative analysis of powder diffraction pattern and to determine the various structural parameters, such as types of crystal system, lattice parameters, and crystallite size of the given materials. Further, to prepare single crystal sample for conducting X-ray diffraction measurements and their mounting on diffractometer. Also learn the preparation of developer and fixer for the film, its cutting and mounting in the camera. In addition, learn the indexing of the developed X-ray photographic film for determination of crystal system, and lattice parameters of the given materials.

Experiments:

1. To prepare the powder sample of the given material and record the powder X-ray diffraction pattern of pure and composite materials. (15 hours)
2. To index the given XRD pattern for determination of the crystal structure and lattice parameters. (15 hours)
3. To determine the crystallite size using Debye –Scherrer formula from a given XRD pattern. (15 hours)
4. To determine the theoretical density of a compound from the given XRD pattern. (15 hours)
5. To prepare a single crystal sample by using a chemical route and prepare the developer and fixer for analyzing photographic film. (15 hours)
6. To record the X-ray diffraction pattern of copper (Cu) and tungsten (W) on a photographic plate and index it for determination of crystal structure and lattice parameters. (15 hours)
7. To record the Laue photograph of KCl and KDP crystals and their indexing. (15 hours)
8. To take the 15° oscillation photograph of KCl and KDP crystal and hence index the reflection spot. (15 hours)

Course Outcomes: Students learn the experimental technique to determine the nature of the given material whether it is amorphous or crystalline. Also, understand to find exact crystal structure of the polycrystalline materials and obtain knowledge about the crystal structure, crystallite size and theoretical density by analyzing the given XRD pattern. Further, students will also gain expertise in developing, mounting and analyzing X-ray diffraction films also be able to find exact crystal structure using manual indexing method.

Reference Books:

1. Elements of X-Ray Diffraction: B. D. Cullity and S. R. Stock (Pearson Education Limited, 2014).

2. Fundamentals of Powder Diffraction and Structural Characterization of Materials: V. K. Pecharsky and Pyzavalij (Springer, 2005).

3. Crystallography for Solid State Physics: Ajit Ram Verma and Onkar Nath Srivastava (New York: Wiley, 1982).

4. X-Ray Spectroscopy An Introduction: B.K. Agarwal (Springer-Verlag, Second Edition 1991).

M.Sc. (PHYSICS) SEMESTER- III
PHY2EL609a
INNOVATIONS IN PHYSICS

Total Lectures 30 **(2 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 nanoscale to large multidimensional universe. 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
Basics of Nanotechnology, Application in medicine, Nano-therapy for combating cancer, What is green nanotechnology? nanotechnology in warfare, nano bots**.**

UNIT- II
Carbon Nanotechnology: Introduction to carbon nanotubes and their applications in various industries.

UNIT- III
Plasmonic materials, Plasmonic solar cells, Overview of current status of research in academia and industry in the field of plasmonics.

UNIT- IV
The composition of the earth's atmosphere, the ozone problem, carbon footprints and how to minimize them.

Course Outcome: After completion of this course, the student will be able to learn the utility of Nano technology in emerging fields of medicine, warfare and nano bots, along specific applicability of carbon nano technology in industries. They will also learn the use of Plasmonics in meeting growing energy needs of various fields. In addition, students will acquire the knowledge of Earth's atmosphere and carbon footprint.

M.Sc. (PHYSICS) SEMESTER- III
PHY2EL609b
Physical Structure of the Universe

Total Lectures 30 **(2 Credits)**

Course Objectives: To introduce newly developing concepts of modern astrophysics to students through application of underlying Physics at basic level for boosting their knowledge and further interest in research and outreach activities.

Unit –I **(8 Lectures)**

Hydrodynamic equilibrium in Sun, nuclear fusion, evolution of stars, spectrum of stars and their classification, stellar plasma, neutron stars, pulsars. Galaxies, clusters and large scale structure of the universe.

Unit –II **(7 Lectures)**

Outline of theories of gravitation: Newtonian, General Relativity, its differences from special relativity. Alternative gravity, Schwarzschild radius. Physics behind black holes and wormholes. Gravitational waves, Laser Interferometer Gravitational-wave Observatory (LIGO).

Unit –III **(8 Lectures)**

Rotational curves of galaxies, need for dark matter, its searches in international experiments, its difference from baryonic matter. Accelerated expansion of the universe, physics of dark energy and alternative explanations.

Unit –IV **(7 Lectures)**

Practical hands-on Projects: Telescopes, their types, theoretical and practical aspects of astrophotography. Practical observational sessions for planets, satellites and stars, and their motion through constellations.

Course Outcomes: The students would be able to understand and appreciate the limitations of Newton's laws of gravitation when applied to solar system and large scale universe. They would realize how this shift in scientific paradigm has created new knowledge like perihelion precession of mercury, gravitational waves, expansion of the universe etc. which cannot be explained in Newton's theory. They would also have the first hand experience in handling telescopes and sky observation and would inculcate spirit of enquiry in natural way.

References:

1. An Introduction to Astrophysics: Baidyanath Basu (Prentice Hall of India, 2003).
2. General Relativity and Gravitational Waves: S. Dhurandhar and S. Mitra (Springer, 2022).

3. Modern Cosmology: Scott Dodelson (Elsevier, 2015).
4. The Planet observer's Handbook: Fred W. Price (Cambridge, 2000).

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- III
PHY2IN611

INTERNSHIP Field Work **(2 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) 2-Year PG Programme- SEMESTER- IV
PHY2CC602
ADVANCED SOLID STATE PHYSICS

Total Lectures 60 **(4 Credits)**

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

UNIT- I **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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) 2-Year PG Programme -SEMESTER-IV
PHY2CC604a
Advanced Mathematical Physics

Total Lectures: 60 **4 Credits**

Course Objectives:

The primary objectives of this course aim at acquiring the stimulating knowledge of the Mathematical Physics and their unification in creating collective study of molecules of materials, in an interesting way. Students must understand the concepts of Mathematics formulate and solve field equations and handle various problems of Physics and Technology.

UNIT – I **(15 Lectures)**

Partial differential equation, Lagrange's linear equation, method of multipliers , Solution of Laplace Poisson , Diffusion and wave equation is Cartesian ,Spherical cylindrical co-ordinates, Green function, Applications of above topics .

UNIT – II **(15 Lectures)**

Fourier series, Fourier integral with different forms, Parsevel's identity for Fourier integrals, Fourier Transforms, Laplace Transforms, Beta and Gamma functions with different forms and relations between them, Application of above topics.

UNIT – III **(15 Lectures)**

Sequence, Convergent sequence, Bounded sequence, Monotonic sequence, Z-transforms and its properties, Inverse Z-transform, solution of difference equations, Convolution, Convolution Property of causal sequence and application of above topics.

UNIT – IV **(15 Lectures)**

Elementary idea of groups and its classes, finite and infinite groups, C_{4v} Multiplications table, Permutations Groups, Representation of groups and it's properties, reducible and Irreducible representations of Groups, Schur's lemma l and ll, Orthogonality theorem and its applications .

Course Outcomes:

After attending this course, students would be able to apply knowledge of mathematical 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 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 Book

1. Advance Engineering Mathematics: Erwin Kreyszig.
2. Mathematical method for Physics and Engineering: Riley.
3. Mathematical method for Physicists: George B. Arfkine.
4. Method of Mathematical Physics: Jeffreys.
5. Mathematical method for physical sciences: Mary L.Boas.
6. Applied Mathematics for Engineer and Physicist: Louis A. Pipes.
7. Mathematical methods for physics: G Arfken.
8. Mathematical Physics: V.Balakrishnam.
9. Mathematical Physics: B.S.Rajput.
10. Elementary Ideas of Group Theory: A.W. Joshi.
11. Concept of Group Theory: W.R.Scott.

M.Sc. (PHYSICS) 2-Year PG Programme- SEMESTER- IV
PHY2EL604b
SPECTROSCOPIC TECHNIQUES AND APPLICATIONS

Total Lectures: 60 **(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, Biomedical, environmental problems are remarkable.

UNIT- I **(15 Lectures)**

Overview of continuous wave (CW) and pulsed lasers, Time-resolved laser spectroscopy, Generation of short laser pulses, Q-switching, Cavity damping, Mode locking, Generation of femtosecond pulses, Spectroscopy in the pico-to-attosecond range, Pump-and-probe spectroscopy and applications.

UNIT- II **(15 Lectures)**

Laser spectroscopy of collision processes, High-resolution laser spectroscopy of collisional line broadening and line shifts, Collision cross-sections of excited atoms and molecules, Optical cooling and trapping of atoms, Optical mollasses, Applications of cooled atoms and molecules, Bose-Einstein condensation (BEC), The atom laser.

UNIT- III **(15 Lectures)**

Fluorescence excitation spectroscopy, Ionization spectroscopy and multi-photon spectroscopy, Laser-induced fluorescence (LIF), Determination of population distributions by LIF, Laser Raman spectroscopy and applications, Linear and nonlinear Raman spectroscopy, Resonance Raman effect, Surface-enhanced Raman scattering, Raman microscopy.

UNIT- IV **(15 Lectures)**

Applications of laser spectroscopy in analytical chemistry, Atmospheric measurements with Light detection and ranging (LIDAR), Spectroscopic detection of water pollution, Laser-induced breakdown spectroscopy (LIBS), Space applications of LIBS (Moon and Mars), Medical applications of Laser, Laser Lithotripsy, X-ray fluorescence spectroscopy (EDXRF/WDXRF).

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 (Springer, Laser Spectroscopy Vol. 2).
2. Laser Physics: Peter W. Milonni, Joseph H. Eberly (Wiley).
3. Laser Induced Breakdown Spectroscopy (LIBS): Concepts, Instrumentation, Data Analysis and Applications: Vivek K. Singh, Durgesh K. Tripathi, Yoshihiro Deguchi, Zhenzhen Wang (Wiley).
4. Applied Raman Spectroscopy: Concepts, Instrumentation, Chemometrics, and Life Science Applications: Vivek K. Singh (Elsevier).
5. X-ray Fluorescence in Biological Sciences: principles, Instrumentation, and Applications: Vivek K. Singh, Jun Kawai, Durgesh K. Tripathi (Wiley).
6. Lasers and Non-Linear Optics: B.B. Laud (New Age International Publishers).

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER- IV
PHY2EL606a
ELECTRONICS- II

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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: Programmeming model. Registers, Accumulator, Flags, Programme 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.

Course Outcomes: The student learns to Programme 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, Programmeming and Applications: RS Gaovkar.
5. Fundamentals of Microprocessors and Microcomputers: B. Ram.
6. Digital Fundamentals: TL Floyd.

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER-IV
PHY2EL606b
LASERS AND OPTO-ELECTRONICS – II

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

Wave Propagation in Planar Waveguides, TE Modes of a Symmetric Step-index Planar Waveguide, Power Distribution and Confinement Factor, Basic Idea of Slab Guide Geometries: Strip, Raised Strip, Embedded Strip, Ridge, Strip Coated Guides. Fabrication of Waveguide in Integrated Optics: Requirements of Substrates, Cleaning of the Substrates, Methods used to produce wave guiding layers, Sputtering, Dipping, Ion Exchange and Migration, Ion Implantation etc.

UNIT IV **(15 Lectures)**

Waveguide Input and Output Couplers: Transverse Couplers, Prism Couplers, Grating Couplers, Thin-film Tapered Couplers, Fiber to Waveguide Couplers.

Electro-Optic Effect: The Electrooptic Effect in KDP crystal: Longitudinal Mode and Transverse Mode, Phase Modulation, Amplitude Modulation, Electrooptic Effect in Lithium Niobate and Lithium Tantalate Crystals.

Acousto-Optic Effect: Theory of Raman-Nath Diffraction, Raman-Nath Acousto-Optic Modulator, Bragg Modulator, Acousto-Optic Deflectors, Acousto-Optic Spectrum Analyzer. Thermo-Optic Effect, Active Waveguide Devices based on Thermo-Optic, Magneto-Optic Effects.

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. Optical Fiber Communications: Gerd Keiser (McGraw-Hill, ISBN:0071007857).
2. Lasers, Fiber Optics and Nonlinear Optics: R. K. Shukla and Anchal Srivastava (Aryabhat Publication House, ISBN: 9789395463522).
3. Fiber Optics and Optoelectronics: R. P. Khare (Oxford University Press, ISBN:9780195669305).
4. Optical Electronics: Ajoy Ghatak and K. Thyagarajan (Cambridge University Press, ISBN:9788185618104).
5. Lasers and Non-Linear Optics: B. B. Laud (New Age International Publishers, ISBN:978812243056-1).
6. Integrated Optics: Theory and Technology: Robert G. Hunsperger (Springer-Verlag Berlin Heidelberg New York Tokyo, ISBN:35401307802).
7. Fiber Optics and Lasers (The Two Revolutions): Ajoy Ghatak and K. Thyagarajan (Macmillan Publishers India Ltd, ISBN:9781403930118).
8. Optical Fiber Communication Systems: R. K. Shukla (MKSES Publication; ISBN: 978-8194930570).
9. Optoelectronic: Fundamentals and Applications: R. K. Shukla (Aryabhat Publication House, ISBN:978-93-95463-10-2).

M.Sc. (PHYSICS) 2-Year PG Programme -SEMESTER-IV
PHY2EL606c
X-rays II (X- RAYS: EMISSION AND ABSORPTION SPECTROSCOPY)

Total Lectures: 60 **(4 Credits)**

Course Objectives:

Main goal of the course is to gain knowledge to understand the principle and applications of x-ray emission and absorption processes along with theories, instrumentation.

UNIT – I **(15 Lectures)**

X-ray emission from thin and thick targets, X-ray emission spectra, X-ray energy level diagram, Diagram and forbidden lines in X-ray spectra, X-ray emission: Chemical shift in emission spectra, X-ray satellites and their origin, parent line and its determination for satellites, Radiative transitions, Auger effect and its consequences in X-ray spectra.

UNIT – II **(15 Lectures)**

X-ray absorption, Absorption coefficients, Nature of the main absorption edge: absorption main edge structure (XAMES), Theory of X-ray absorption near edge structure (XANES), Theory and applications of Extended X-ray absorption fine structure (EXAFS): Geometric constraints on bond lengths, Constraints on the coordination environment.

UNIT – III **(15 Lectures)**

Resonant and non-resonant X-rays Emission Spectroscopy, Appearance Potential Spectroscopy, Width of Fine Structure of Emission Lines, Anisotropic X-ray Emission Lines, Nuclear Finite–size Effects, Absorption Spectra Recording.

UNIT – IV **(15 Lectures)**

Energy Dispersive X-ray Spectroscopy (EDAX) and Wavelength Dispersive Spectroscopy (WDX): Instrumentation, Sample Preparation, Data Interpretation, Applications and Limitations. X-ray photoelectron spectroscopy (XPS): Principle, Instrumentation, data interpretation and applications

Course Outcomes: The students shall learn the principles of interaction of X-rays with matter. They will gain knowledge about x-ray emission from and absorption. They will also understand the nature of the X-rays absorption and emission spectra, near edge structure, main edge structure and Extended X-ray absorption fine structure along with their broad applications using various techniques to understand the materials properties.

Reference Books:

1. X-Ray Absorption and X-Ray Emission Spectroscopy: Theory and Applications: Jeroen A. Van Bokhoven, Carlo Lamberti (John Wiley & Sons 2016).
2. Advances in X-Ray Spectroscopy: C. Bonnelle And C. Mandé (Elsevier, 1982).

3. X-ray absorption spectroscopy (principles, applications, techniques of EXAFS, SEXAFS and XANES): D.C. Konnigsberger and R. Prins (John Wiley and Sons, NY 1988).
4. X-Ray Spectroscopy An Introduction : B.K. Agarwal (Springer-Verlag, Second Edition 1991).

M.SC. (PHYSICS) 2-YEAR PG PROGRAMME -SEMESTER- IV
PHY2MT608
MASTER Thesis Dissertation

(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.

Detailed Course Outline
for
1 Year PG Programme
(M.Sc. in Physics)

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER-I
PHY1CC501
Mathematical Physics

Total Lectures: 60 **(4 Credits)**

Course Objectives:

The primary objectives of this course aim at acquiring the stimulating knowledge of the Mathematical Physics and their unification in creating collective study of molecules of materials, in an interesting way. Students must understand the concepts of Mathematics formulate and solve field equations and handle various problems of Physics and Technology.

UNIT – I **(15 Lectures)**

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.

UNIT – II **(15 Lectures)**

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

UNIT – III **(15 Lectures)**

Ordinary point and singularities of a linear differential equation **,** Power series, solution of second order differential equations (Bessel, Legendre, Laguerre and Hermit equations)**,** Orthonormality, Rodrigues' formula and other properties of Legendre, Bessel and Laguerre functions and polynomials

UNIT – IV **(15 Lectures)**

Interpolation formula for finite difference with equal and unequal intervals, Errors and accuracy tests in numerical analysis, the iterative algorithms for solving equations and finding roots, Discrete and Fast Fourier Transform.

Course Outcomes:

After attending this course, students would be able to apply knowledge of mathematical 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 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 Book

1. Advance Engineering Mathematics: Erwin Kreyszig.
2. Mathematical method for Physics and Engineering: Riley.
3. Mathematical method for Physicists: George B. Arfkine.
4. Method of Mathematical Physics: Jeffreys.
5. Mathematical method for physical sciences: Mary L.Boas.
6. Applied Mathematics for Engineer and Physicist: Louis A. Pipes.
7. Mathematical methods for physics: G Arfken.
8. Mathematical Physics: V.Balakrishnam.
9. Mathematical Physics: B.S.Rajput.

M.Sc. (PHYSICS) 1-Year PG Programme- SEMESTER- I
PHY1CC505
SOLID STATE PHYSICS

Total Lectures 60 **(4 Credits)**

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

UNIT- I **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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 Tc super-conductors. Dislocation in Solids: Dislocations, Edge and screw dislocations, Burger vectors, Dislocation stress and strain, Fields of dislocations, Dislocation multiplication.

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) 1-Year PG Programme- SEMESTER- I
PHY1CC513
NUCLEAR PHYSICS

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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) 1-Year PG Programme -SEMESTER- I
PHY1EL605a
ELECTRONICS - I

Total Lectures 60 **(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 **(15 Lectures)**

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. The Transistor Hybrid Pi Model. Amplifiers: Difference Amplifiers; Broadband Amplifiers, Methods for achieving Broad-banding; Emitter Follower at High Frequencies. Operational Amplifiers and its Applications.

UNIT- II **(15 Lectures)**

Nanoelectronics: Fractional Quantum Hall Effect, Quantum Interference Transistor, Artificial Atoms, Coulomb Blockade, Single Electron Transistor, Quantum Dots, Spintronics. High Electron Mobility Transistor. Mesoscopic Physics, MODFET.
Quantum AI: Qubits, Multiple Qubits, Swap operation, distinction between Classical and Quantum Computation, Quantum Teleportation, Actualizing Quantum Computers: some examples, Artificial Intelligence: Definition, Actualization, Applications, why Quantum AI?.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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) 1-Year PG Programme -SEMESTER-I
PHY1EL605b
LASERS AND OPTO-ELECTRONICS – I

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

Essential Criterion to Observe Nonlinear Optical Effects. First Experimental Demonstration of Nonlinear 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.

UNIT- III **(15 Lectures)**

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, Basic Idea of Multiphoton Processes.

UNIT- IV **(15 Lectures)**

Ray Propagation in Step-Index Fibers, Ray Propagation in Graded-Index Fibers, Concept of Normalized Frequency, V-Parameter, Pulse Dispersion in Step Index Fibers, Intersymbol Interference, Material Dispersion, Waveguide Dispersion, Concept of Dispersion shifted Fibers and Dispersion Flattened Fibers, Optical Fiber material, Fabrication of Optical Fibers, Fiber Connectors and Splices.

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) 1-Year PG Programme -SEMESTER- I
PHY1EL605c
X-rays I (X-RAY CRYSTALLOGRAPHY)

Total Lectures: 60 **(4 Credits)**

Course Objectives: The primary objectives of this course are to gain knowledge to understand the basics of x-ray scattering and dispersion phenomena and their theories. This course also provides the fundamental and advanced understanding of X-crystallography using various methods.

UNIT – I **(15 Lectures)**

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. Dispersion theory applied to x-rays, Anomalous dispersion, The forced, Damped oscillations of an electron and dielectric constant of the medium.

UNIT – II **(15 Lectures)**

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.

UNIT – III **(15 Lectures)**

Sample preparation for phase identification and quantitative analysis, assigning hkl and cell parameters for refinement, Profile fitting using Le Bail and Pawley method, The phase problem and various methods of its solution, trial and error methods, optical method, Fourier and Patterson methods.

UNIT – IV **(15Lectures)**

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.

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-ray 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: Principles and Practice: William Clegg, Alexander J Blake, Jacqueline M Cole, John S O Evans, Peter Main, Simon Parsons, David J Watkin (Oxford University Press, Second edition, 2009).
2 X-rays in theory and experiment: Arthur H. Compton and Samuel K. Allison, (Princeton, N.J., Van Nostrand, 1963).
3. Elements of X-ray crystallography: Leonid V Azároff (New York, McGraw-Hill, 1968).
4. Principle and Applications of Powder Diffraction: Abhram Clearfield, Joseph Reibenspies and Nattanai Bhuvanesh (Willy Publication, 2009).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- I
PHY1EL613a

ELECTRONICS I– LAB (2 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

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, Programmeming and Applications: RS Gaovkar.
5. Fundamentals of Microprocessors and Microcomputers: B. Ram.
6. Digital Fundamentals: TL Floyd.

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- I
PHY1EL613b

Lasers and Optoelectronics I- LAB **(2 Credits)**

Course Objectives: This course is aimed at rendering skill on the experimental techniques related to lasers, optical fibres and fibre optic communication.

Any SIX of the following experiments are to be performed.
1. Study of Characteristics of LED and Pin Photo Detector
3. Study of Attenuation In Optical Fibers
4. To Find Numerical Aperture of Optical Fibers
5. To find wavelength of He-Ne laser using a diffraction grating.
6. To obtain expanded collimated light from He-Ne laser over a distance of 2m.
7. To Study Micro-bending Losses In An Optical Fiber
8. Study of Pulse Amplitude Modulation And Time
9. Study of Digital Data Communication
10. Study of Ask Modulation and Demodulation
11. To calculate the beam divergence and spot size of the given laser beam.
(vlab.amrita.edu)

Course Outcome: 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 lignment, laser parameters and properties, 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).
10. Optical Fiber Communication: R. P. Khare (Oxford University Press).

M.Sc. (PHYSICS) 1-YEAR PG PROGRAMME -SEMESTER- I
PHY1EL613c

X-RAYS I- LAB **(2 Credits)**

Course Objectives: The main objectives of this course is to acquire detail knowledge about quantitative and qualitative analysis of powder diffraction pattern and to determine the various structural parameters, such as types of crystal system, lattice parameters, and crystallite size of the given materials.

Experiments:

1. To prepare the powder sample of the given material and record the powder X-ray diffraction pattern of pure and composite materials. (15 hours)
2. To index the given XRD pattern for determination of the crystal structure and lattice parameters. (15 hours)
3. To determine the crystallite size using Debye –Scherrer formula from a given XRD pattern. (15 hours)
4. To determine the theoretical density of a compound from the given XRD pattern. (15 hours)

Course Outcomes: Students learn the experimental technique to determine the nature of the given material whether it is amorphous or crystalline. Also, understand to find exact crystal structure of the polycrystalline materials and obtain knowledge about the crystal structure, crystallite size and theoretical density by analyzing the given XRD pattern.

Reference Books:

1. Elements of X-Ray Diffraction: B. D. Cullity and S. R. Stock (Pearson Education Limited, 2014).
2. Fundamentals of Powder Diffraction and Structural Characterization of Materials: V. K. Pecharsky and Pyzavalij (Springer, 2005).
3. Crystallography for Solid State Physics: Ajit Ram Verma and Onkar Nath Srivastava (New York: Wiley, 1982).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER-I
PHY1VC511
Laser, Optical fibers and Sensors

Total Lectures: 30 **2 Credits**

Course Objectives:

The primary objectives of this course aim at acquiring the stimulating knowledge of fiber optics and laser technology. Students must understand the importance of laser, fiber optical methods and sensors in all spheres of life i.e. various communication requirements, medical, travel etc.

UNIT – I **(10 Lectures)**

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, Laser in THz generation.

UNIT – II **(8 Lectures)**

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.

UNIT – III **(6 Lectures)**

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.

UNIT – IV **(6 Lectures)**

Optical Sensors, Advantages of optical Sensors, Properties of Sensors, Classification of Sensors: first, second and third generation sensors, and applications of fiber sensors.

Course Outcomes:

After attending this course, 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. Principles of Laser: Orazio Svelto (Springer).
7. Introduction to Optics: Anchal Srivastava (New Age International Publishers, New Delhi).
8. Laser, Theory and Applications: K. Thyagarajan (Springer Berlin Heidelberg).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- III
PHY1VC511b
Introduction to Sky Watching

Total Lectures: 30 **Credits: 2**

Course Objectives: To build a clear understanding of science through inquisitiveness arising from basic sky observations along with the principles of modern astronomy.

Unit –I **(8 Lectures)**

Objects in night sky. Identification of celestial sphere and motion of sky objects, Constellations. Solar system bodies including planets, satellites, asteroids and comets, and their motions. Exo-planets. Working of International Space Station, Various periodic comet shower events.

Unit –II **(7 Lectures)**

Development of Astronomy from ancient to modern times, Nakshatras in ancient India, main contributions of Aryabhat, Bhaskar, Kepler, Newton and Einstein in astronomy. Galileo's observation of Jupiter's moons.

Unit –III **(8 Lectures)**

Elementary ideas about our Milky Way and its neighbors. Black holes, dark matter and basic difference between dark matter and dark energy, and between dark matter and normal matter. Searches for Extra-terrestrial life.

Unit –IV **(7 Lectures)**

Telescopes, types, Hubble Space Telescope, James Webb Space Telescope, basic techniques of astrophotography. Practical observational sessions for planets, satellites and stars, and their motion in the background of constellations.

Course Outcomes: The students would enjoy the thrill and appreciate the spirit of scientific inquiry by quenching their curiosity about the mysteries behind the sky objects.

References:

1. Gunakar Muley: Aakash darshan (Rajkamal Prakashan, 2003).
2. The Physical Universe: Frank Shu (University Science Books, 1982).
3. A Brief History of Time: Stephen Hawking (Bantam, 1987).
4. The Grand Design: Stephen Hawking and Leonard Mlodinow (Bantam Books, 2010).

M.Sc. (PHYSICS) 1-Year PG Programme- SEMESTER- II
PHY1CC602
ADVANCED SOLID STATE PHYSICS

Total Lectures 60 **(4 Credits)**

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

UNIT- I **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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) 1-Year PG Programme -SEMESTER- II
PHY1CC612
ADVANCED QUANTUM MECHANICS

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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.

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) 1-Year PG Programme- SEMESTER- II

PHY1CC614
ADVANCED NUCLEAR PHYSICS

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

Basic interactions and their mediating quanta, Types of particles and their families, Concept of Feynman diagrams and their applications, 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. Feynman Diagrams

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 (S. Chand Publication, First edition).
7. Nuclear & Particle Physics: An Introduction: B. Martin (Willey, 2006).
8. Introduction to Elementary Particles: D. Griffiths (Academic Press, Second edition, 2008).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- II
PHY1EL606a
ELECTRONICS- II

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

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.

UNIT- IV **(15 Lectures)**

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: Programmeming model. Registers, Accumulator, Flags, Programme 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.

Course Outcomes: The student learns to Programme 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, Programmeming and Applications: RS Gaovkar.
5. Fundamentals of Microprocessors and Microcomputers: B. Ram.
6. Digital Fundamentals: TL Floyd.

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER-II
PHY1EL606b
LASERS AND OPTO-ELECTRONICS – II

Total Lectures 60 **(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 **(15 Lectures)**

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.

UNIT- II **(15 Lectures)**

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.

UNIT- III **(15 Lectures)**

Wave Propagation in Planar Waveguides, TE Modes of a Symmetric Step-index Planar Waveguide, Power Distribution and Confinement Factor, Basic Idea of Slab Guide Geometries: Strip, Raised Strip, Embedded Strip, Ridge, Strip Coated Guides. Fabrication of Waveguide in Integrated Optics: Requirements of Substrates, Cleaning of the Substrates, Methods used to produce wave guiding layers, Sputtering, Dipping, Ion Exchange and Migration, Ion Implantation etc.

UNIT IV **(15 Lectures)**

Waveguide Input and Output Couplers: Transverse Couplers, Prism Couplers, Grating Couplers, Thin-film Tapered Couplers, Fiber to Waveguide Couplers.

Electro-Optic Effect: The Electrooptic Effect in KDP crystal: Longitudinal Mode and Transverse Mode, Phase Modulation, Amplitude Modulation, Electrooptic Effect in Lithium Niobate and Lithium Tantalate Crystals.

Acousto-Optic Effect: Theory of Raman-Nath Diffraction, Raman-Nath Acousto-Optic Modulator, Bragg Modulator, Acousto-Optic Deflectors, Acousto-Optic Spectrum Analyzer. Thermo-Optic Effect, Active Waveguide Devices based on Thermo-Optic, Magneto-Optic Effects.

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. Optical Fiber Communications: Gerd Keiser (McGraw-Hill, ISBN: 0071007857).
2. Lasers, Fiber Optics and Nonlinear Optics: R. K. Shukla and Anchal Srivastava (Aryabhat Publication House, ISBN: 9789395463522).
3. Fiber Optics and Optoelectronics: R. P. Khare (Oxford University Press, ISBN: 9780195669305).
4. Optical Electronics: Ajoy Ghatak and K. Thyagarajan (Cambridge University Press, ISBN: 9788185618104).
5. Lasers and Non-Linear Optics: B. B. Laud (New Age International Publishers, ISBN: 978812243056-1).
6. Integrated Optics: Theory and Technology: Robert G. Hunsperger (Springer-Verlag Berlin Heidelberg New York Tokyo, ISBN:35401307802).
7. Fiber Optics and Lasers (The Two Revolutions): Ajoy Ghatak and K. Thyagarajan (Macmillan Publishers India Ltd, ISBN:9781403930118).
8. Optical Fiber Communication Systems: R. K. Shukla (MKSES Publication; ISBN: 978-8194930570).
9. Optoelectronic: Fundamentals and Applications: R. K. Shukla (Aryabhat Publication House, ISBN:978-93-95463-10-2).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER-II
PHY1EL606c
X-rays II (X- RAYS: EMISSION AND ABSORPTION SPECTROSCOPY)

Total Lectures: 60 **(4 Credits)**

Course Objectives:

Main goal of the course is to gain knowledge to understand the principle and applications of x-ray emission and absorption processes along with theories, instrumentation.

UNIT – 1 **(15 Lectures)**

X-ray emission from thin and thick targets, X-ray emission spectra, X-ray energy level diagram, Diagram and forbidden lines in X-ray spectra, X-ray emission: Chemical shift in emission spectra, X-ray satellites and their origin, parent line and its determination for satellites, Radiative transitions, Auger effect and its consequences in X-ray spectra.

UNIT – 2 **(15 Lectures)**

X-ray absorption, Absorption coefficients, Nature of the main absorption edge: absorption main edge structure (XAMES), Theory of X-ray absorption near edge structure (XANES), Theory and applications of Extended X-ray absorption fine structure (EXAFS): Geometric constraints on bond lengths, Constraints on the coordination environment.

UNIT – 3 **(15 Lectures)**

Resonant and non-resonant X-rays Emission Spectroscopy, Appearance Potential Spectroscopy, Width of Fine Structure of Emission Lines, Anisotropic X-ray Emission Lines, Nuclear Finite–size Effects, Absorption Spectra Recording.

UNIT – 4 **(15 Lectures)**

Energy Dispersive X-ray Spectroscopy (EDAX) and Wavelength Dispersive Spectroscopy (WDX): Instrumentation, Sample Preparation, Data Interpretation, Applications and Limitations. X-ray photoelectron spectroscopy (XPS): Principle, Instrumentation, data interpretation and applications

Course Outcomes: The students shall learn the principles of interaction of X-rays with matter. They will gain knowledge about x-ray emission from and absorption. They will also understand the nature of the X-rays absorption and emission spectra, near edge structure, main edge structure and Extended X-ray absorption fine structure along with their broad applications using various techniques to understand the materials properties.

Reference Books:

1. X-Ray Absorption and X-Ray Emission Spectroscopy: Theory and Applications: Jeroen A. Van Bokhoven, Carlo Lamberti (John Wiley & Sons, 2016).
2. Advances in X-Ray Spectroscopy: C. Bonnelle And C. Mandé (Elsevier, 1982).

3. X-ray absorption spectroscopy (principles, applications, techniques of EXAFS, SEXAFS and XANES): D.C. Konnigsberger and R. Prins, (John Wiley and Sons, NY, 1988).
4. X-Ray Spectroscopy An Introduction by B.K. Agarwal (Springer-Verlag, Second Edition 1991).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- II
PHY1EL610a

ELECTRONICS II– LAB **(2 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 Op-amp Applications
2.	Study of Analog To Digital Converters
3.	Study of Digital To Analog Converters
4.	Study of Multi-vibrators
5.	Study of 555 Timer
6.	Study of Alu Ic 74181
7.	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, Programmeming and Applications: RS Gaovkar.
5. Fundamentals of Microprocessors and Microcomputers: B. Ram.
6. Digital Fundamentals: TL Floyd.

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- II
PHY1EL610b

Laser and Optoelectronics II- LAB (2 Credits)

Course Objectives: This course is aimed at rendering skill on the experimental techniques related to lasers, optical fibres and fibre optic communication.

Any SIX of the following experiments are to be performed in Semester II.

1. Study of Frequency Response of Optical Receiver.
2. Study of Noise in an Optical Receiver.
3. To demonstrate Abbe's Theory of Self Imaging.
4. To study Spatial Filtering using a wire mesh.
5. To Study Diffraction Pattern Using a Software Controlled Set-Up Self-Imaging
6. Study of NRZ and its Detection
7. Study of RZ and its Detection
8. Study of Manchester Coding and its Detection
9. To find the numerical aperture of a given optical fibre and hence to find its acceptance angle. (vlab.amrita.edu)
10. To determine the wavelength of laser beam using Michelson Interferometer (vlab.amrita.edu)
11. Plot the refractive index profile and Numerical aperture profile for α = 1,2,3,4 and 1000 using MATLAB.
12. study the material dispersion in silica fibre using MATLAB.

Course Outcome: 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 lignment, laser parameters and properties, 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).
10. Optical Fiber Communication: R. P. Khare (Oxford University Press).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- II
PHY1EL610c

X-RAYS II- LAB **(2 Credits)**

Course Objectives: The main objectives of this course is to prepare single crystal sample for conducting X-ray diffraction measurements and their mounting on diffractometer. Also learn the preparation of developer and fixer for the film, its cutting and mounting in the camera. In addition, learn the indexing of the developed X-ray photographic film for determination of crystal system, and lattice parameters of the given materials.

Experiments:

1. To prepare a single crystal sample by using a chemical route and prepare the developer and fixer for analyzing photographic film. (15 hours)
2. To record the X-ray diffraction pattern of copper (Cu) and tungsten (W) on a photographic plate and index it for determination of crystal structure and lattice parameters. (15 hours)
3. To record the Laue photograph of KCl and KDP crystals and their indexing. (15 hours)
4. To take the 15° oscillation photograph of KCl and KDP crystal and hence index the reflection spot. (15 hours)

Course Outcomes: Students will gain expertise in developing, mounting and analyzing X-ray diffraction films also be able to find exact crystal structure using manual indexing method.

Reference Books:

1. Elements of X-Ray Diffraction: B. D. Cullity and S. R. Stock (Pearson Education Limited, 2014).
2. Fundamentals of Powder Diffraction and Structural Characterization of Materials: V. K. Pecharsky and Pyzavalij (Springer, 2005).
3. Crystallography for Solid State Physics: Ajit Ram Verma and Onkar Nath Srivastava (New York: Wiley, 1982).
4. X-Ray Spectroscopy An Introduction: B.K. Agarwal (Springer-Verlag, Second Edition, 1991).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- II
PHY1IE512a
INTRODUCTION TO ELECTRONIC COMMUNICATION

Total Lectures 30 **(2 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 **(8 Lectures)**

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.

UNIT- II **(7 Lectures)**

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

UNIT- III **(8 Lectures)**

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.

UNIT- IV **(7 Lectures)**

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

Course Outcomes: Understanding of, signal representation in both time and frequency domains, 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 (Pearson Education).
2. Kennedy's Electronic communication systems: George Kennedy, Bernard Devis, SRM Prasanna (Mc Graw Hill Education).

M.Sc. (PHYSICS) 1-Year PG Programme -SEMESTER- II
PHY1IE512b
ELEMENTS OF SPACE PHYSICS

Total Lectures: 30 **2 Credits**

Course Objectives: This course provides an in-depth understanding of the Sun, solar phenomena, and their interaction with the Earth. It equips students with knowledge about solar activity and its effects on space weather and terrestrial systems.

UNIT - I
Physical properties of the Sun: Solar size and mass, solar rotation, solar material, Sun`s core, photosphere, chromosphere, corona, solar magnetic field, solar wind and characteristics.

UNIT - II
Solar Activity and Variability: Solar magnetic activity, sunspots and their properties, solar magnetic fields, and differential rotation; solar cycle and its phases, solar dynamo theory; Periodicities and long-term variability of solar activity.

UNIT - III
Solar Transients: Solar flares and their classification, coronal mass ejections (CMEs); prominences, faculae, corpuscular clouds interaction with planetary systems, and formation of the heliosphere.

UNIT - IV
Solar-Earth Interaction and Space Weather: Solar storms, impact of solar activity on the ionosphere, magnetosphere and atmosphere, geomagnetic storms and substorms; aurora formation and dynamics; Space weather: causes and consequences, space climate.

Course Outcomes: Upon completing this course, students will:
1. Gain detailed knowledge of the Sun, its structure, and activity.
2. Understand the interaction between solar activity and the Earth’s environment.
3. Develop skills to analyze space weather phenomena and their impact on technology.

Reference Books
1. The Sun: A Laboratory for Astrophysics by J. T. Schmelz.
2. Introduction to Space Weather by Mark Moldwin
3. Elementary Space Physics by R. P. Singhal
4. Solar Activity and Earth`s Climate by Rasmus E. Benestad