M. Sc. PHYSICS

COURSE STRUCTURE AND SCHEME OF THE PROGRAMME

DEPARTMENT OF PHYSICS
DR B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY
JALANDHAR – 144011

PREFACE

Department of Physics was established in the year 1989, in the very first year of inceptions of the then "Dr. B.R. Ambedkar Regional Engineering College, Jalandhar", to provide the basic Physics inputs to the B.Tech students of all the disciplines. M.Tech (Part-Time) in Material Science and Technology was also started in the year 2001. With up gradations of Regional Engineering College, Jalandhar to National Institute of Technology, Jalandhar (Deemed University), the courses offered to B.Tech/M.Tech programmes were revised in accordance with the stipulations made in National Institute of Technology, rules, 2002.

Department has started M.Sc. Physics Programme from the academic session i.e. Aug 2006-2007. M.Sc Physics programme comprises of courses belonging to wide range of fields of Physical science and a dissertation work in the last semester which trained and motivate students to pursue career in the field of research and development. The department of Physics has expertise in condensed matter physics, nuclear and radiation physics, plasma physics and high energy physics. Faculties are working both in experimental and theoretical physics.

The field of materials science is an interdisciplinary field of sciences and engineering fields and has different fascinating applications e.g. ferroelectric materials in antenna application of ISRO project, renewable energy materials, memory devices, superconductivity, magneto-resistance, spintronics etc. It is foremost to have high quality samples with desired properties and have good expertise to synthesize different materials and investigate their different properties. It is essential to explore advanced functional materials where one can tune their properties by different means and understand the correlation between different order parameters. One of the research group in the department is working on functional oxide materials which includes multiferroic, magnetoelectrics, magnetic materials, ferroelectric, piezoelectric, pyroelectric, superconductivity, phase transitions and strongly correlated electron system. Faculty member has experience to develop different homemade measurements like superconductivity, high resistivity etc. Another group of experimental condensed matter physics is working on the bulk and thin films of oxides. The research work is focused on magnetic materials, correlated electron system and transparent conducting oxides. The research work involves use of many experimental techniques along with accelerators for swift heavy ion irradiation and characterization of materials using techniques such as NEXAFS, XAS, XPS, XRD etc. Another research group in field of experimental condensed matter physics is involved in the study of electro-optic properties ferroelectric and Nematic Liquid crystals liquid crystals materials, study of dielectric properties in Liquid crystals and its composites, morphological and optical effects in polymer dispersed liquid crystals composites, the study of Polymer and Nano materials stabilized Blue Phase Liquid Crystals and synthesis and characterization of Nanofluids. One of the research group is working on nano-physics. Another group is working on design and fabrication of devices which is based on thermodynamic process at different environmental conditions, fabrication of low dimensional devices and their measurement at room temperature. Theoretical condensed matter physics group is working on quantum liquids, quantum Monte Carlo, electronic structure and strongly correlated systems, and nanomagnetism & magnonics.

One of the research groups in the department is working in the field of Plasma Physics. We know that plasma finds it application in many diverse fields like space, controlled thermonuclear fusion, plasma processing (thin film deposition, plasma based lighting, plasma chemistry, plasma spray), environment and health science, material synthesis (nanotechnology), switches, relays, antennas, power systems, waste processing etc. Further Plasma related experiments are excellent vehicles for illustrating and understanding complex physical concepts and for exploring cutting-edge topics in physics, Materials Sciences, Computer Sciences and Mathematics. It is clear that plasma science and technology encompass immense diversity, pervasiveness and potential. Already plasma technologies have a significant contribution in the industry, with the annual world market size approaching $ 200 billion. Consensus has already emerged among the scientific community that plasma-based technology would be the most dominant technology in the 21st century because plasma assisted devices are more efficient.

Department of Physics has also research group working extensively in radon studies pollution in the human environment and also for earthquake prediction, track etching and annealing studies in minerals and applications in geothermal studies, health risk assessments due to natural radiation dose from the environment, heavy ion radiation damage studies in track recorders and assessment of radiation dose due to building materials, radiation induced modifications in polymeric track detectors, physico-chemical investigations and the estimation of uranium and other heavy toxic metals in drinking water samples for health risk assessments. The group of theoretical nuclear physics is involved in study of superdeformed nuclei.

The Department is also involved the field High Energy Physics (HEP) consisting of very active groups in both theoretical and experimental physics. The research group of theoretical high energy physics is mainly working the non-perturbative aspects of Quantum Chromodynamics (QCD). QCD represents a remarkable synthesis of the various ideas developed about hadronic physics and has given a successful description in the deep inelastic regime. However, its success in the low energy regime which pertains to the non-perturbative structure of QCD has been limited to some extent. The chiral constituent quark model probes the regime between the confinement scale and the chiral symmetry breaking scale, therefore providing vital clues for the non-perturbative structure of QCD. A detailed investigation pertaining to ``proton spin problem" and related issues would throw considerable light on the effective degrees of freedom of QCD in the non-perturbative regime. Research group also investigating the mass modification of hadrons at finite density and temperature of the hadronic medium. The applications of these studies are for the heavy-ion collision experiments as well as for understanding the properties of astrophysical objects for example neutron stars. The experimental HEP group is participating in elementary particle physics research in Compact Muon Solenoid (CMS) experiment at the European Center for Nuclear Research (CERN). The experimental group has been actively pursuing the study of the two particle angular correlations which provides very important information for characterizing QCD in the energy regime of Tera-Electron Volts (TeV), especially about the mechanism of hadronization and possible collective effects due to the high particle densities reached in these collisions. The measurement of the multiparticle correlations in these high energy collisions will throw a very important light on the understanding of the underlying mechanism of particle production.

(Dr. Harleen Dahiya)
Chairman, Board of Studies
Dr. B.R. Ambedkar
National Institute of Technology
Jalandhar – 144011

Dated: 01.03.19

VISION OF DEPARTMENT

The department is committed for high quality teaching and pursuit of excellence in research. We pledge to serve the nation and society by providing skilled and well developed human resource through brilliance in technical education and research.

MISSION OF DEPARTMENT

- To encourage innovation and research through projects and developmental activities with industries, institutions and government.
- To inculcate moral and ethical values with a sense of competitiveness, self-confidence and sincerity among the students to make them a good human and a good citizen.
- To produce excellent scientists, engineers, innovators, entrepreneurs and academicians for the growth of the society.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

After successful completion of program, graduates will be able to:

PEO 1	Work in the infrastructure development projects.
PEO 2	Pursue higher studies and crack competitive exams.
PEO 3	Contribute in teaching, research and other developmental activities of electronics & communication engineering and its allied fields.
PEO 4	Work in the multicultural and multidisciplinary groups for the sustainable development and growth of electronics and communication engineering projects and profession.

PROGRAMME OUTCOMES (PO)

PO 1	Engineering/Scientific knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
PO 2	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems Reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO 3	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO 4	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO 5	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO 6	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of and need for sustainable development.
PO 8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO 9	Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	Communication:

	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Structure and Scheme of the Programme
M.Sc. Physics

SEMESTER I

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PH-511	Classical Mechanics	3	1	-	3	4
2.	PH-512	Mathematical Physics	3	1	-	3	4
3.	PH-513	Electronics	3	1	-	3	4
4.	PH-514	Computational Techniques	3	1	-	3	4
5.	PH-541	Electronics Lab.	-	-	6	3	3
6.	PH-542	Computer Lab.	-	-	6	3	3
Total Credits in First Semester							22

SEMESTER II

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PH-515	Quantum Mechanics-I	3	1	-	3	4
2.	PH-516	Solid State Physics-I	3	1	-	3	4
3.	PH-524	Statistical Physics	3	1	-	3	4
4.	PH-518	Electrodynamics	3	1	-	3	4
5.		Elective-I	3	-	-	3	3
6.	PH-543	Solid State Physics Lab.	-	-	6	3	3
Total Credits in Second Semester							22

SEMESTER III

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PH-519	Quantum Mechanics-II	3	1	-	3	4
2.	PH-520	Solid State Physics-II	3	1	-	3	4
3.	PH-521	Plasma Physics	3	1	-	3	4
4.	PH-522	Nuclear Physics	3	1	-	3	4
5.	PH-545	Nuclear Physics Lab.	-	-	6	3	3
6.	PH-546	Plasma Lab.	-	-	6	3	3
Total Credits in Third Semester							22

SEMESTER IV

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PH-523	Particle Physics	3	1	-	3	4
2.	PH-517	Atomic and Molecular Spectroscopy	3	1	-	3	4
3.		Elective -II	3	-	-	3	3
4.	PH-544	Spectroscopy Lab.	-	-	6	3	3
5.	PH-561	Project	-	-	-	-	10
Total Credits in Fourth Semester							24

List of Electives - I

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PH- 535	Digital Electronics	3	0	-	3	3
2.	PH- 536	Nuclear Instrumentation	3	0	-	3	3
3.	PH-540	Polymer & Liquid Crystals	3	0	-	3	3
4.	PH-538	Nanostructured Materials	3	0	-	3	3
5.	PH-539	Experimental Techniques in Physics	3	0	-	3	3
6.	PH-551	Mathematical Physics-II	3	0	-	3	3

List of Electives - II

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PH-531	Nuclear Accelerator and Radiation Physics	3	0	-	3	3
2.	PH-532	Opto Electronics	3	0	-	3	3
3.	PH-533	Microwaves	3	0	-	3	3
4.	PH-537	Quantum Field Theory	3	0	-	3	3

5.	PH-534	Physics of Polymers	3	0	-	3	3

Regular Courses

Course code	PH-511
Course title	Classical Mechanics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
This course aims at providing knowledge of Classical Mechanics to the students so that they can understand the Lagrangian and Hamiltonian formalism and also their applications in various branches of Physics.

Course Outcomes: Following are outcomes of the course:

CO 1	Execute the mechanics of system of particles, the variational principle, Lagrangian and Hamiltonian formulations.
CO 2	Solve various problems related with central force including kepler's laws of motion.
CO 3	Make understanding about the rigid body dynamics including problems & Euler's equation of motion.
CO 4	Execute the Classical approach to Special theory of relativity, various transformation equations and Lagrangian and Hamiltonian of a relativistic particle.
CO 5	Study about the Legendre Transformations and Hamilton's equations of motion, as well as Principle of least action.
CO 6	Execute the theories and mathematical equations related to Canonical Transformations & Hamilton-Jacobi theory.

Syllabus

Lagrangian Mechanics: Newton's laws of motion, mechanics of a system of particles, constrain, D'Alembert's principle and Lagrange equations of motion. Velocity dependent potentials and dissipation function. Some applications of Lagrangian formulation, Hamilton's principle, derivation of Lagrange equations from the Hamilton's principle. Conservation theorems and symmetry properties.

Central Force Problem : Two body central force problem, reduction to equivalent one body problem, the equation of motion and first integrals, the equivalent one dimensional problem and classification of orbits. The differential equation for the orbit and integrable power-law potential. The Kepler problem. Scattering in a central force.

Rigid Body Dynamics: The independent coordinates of a rigid body, orthogonal transformations, the Euler's angles. Euler's theorem on the motion of rigid body, finite and infinitesimal rotations, rate of angular momentum and kinetic energy about a point for a rigid body, the inertia tensor and moment of inertia, the eigenvalues of moment of the inertia tensor and the principal axes transformation. Euler’s equations of motion, torque free motion of a rigid body.

Canonical Transformations and Hamilton-Jacobi Theory: Legendre transformation and Hamilton’s equations of motion, cyclic coordinates and conservation theorems, derivation of Hamilton’s equations from a variational principle, the principle of least action. The equation of canonical transformations, examples of canonical transformations, Poisson brackets. Equations of motion, infinitesimal canonical transformation and conservation theorems in the Poisson bracket formulation. The Hamilton-Jacobi equation for Hamilton's Principal Function, The harmonic Oscillator Problem as an example of the Hamilton-Jacobi method.

Books Recommended:

1. Goldstein H “Classical Mechanics”, Narosa Publishing House, New Delhi, (2004).
2. Landau L D and Lifshitz E M “Mechanics”, Pergamon Press, Oxford, (1989).
3. Aruldhas G “Classical Mechanics”, PHI Learning Pvt. Ltd., Delhi, (2013).
4. Rana N C and Joag P S “Classical Mechanics”, Tata McGraw-Hill Publishing Co., New Delhi.
5. Shankara Rao “Classical Mechanics”, Prentice Hall of India, New Delhi, (2005).

Course code	PH-512
Course title	Mathematical Physics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course "Mathematical Physics" is to train the students in the mathematical methods which are routinely used in the study of Physical Sciences. The course will help the students in understanding the fundamentals of mathematical methods and how to use them in problems routinely encountered in Physics. Students will be familiar with vectors, tensors, complex analysis, Fourier series, integral transforms, special functions and fundamentals of group theory.

Course Outcomes: Following are outcomes of the course:

CO 1	Students will have understanding about the vector calculus. They will learn about the general coordinate transformation and the relevant transformation equations. This will help them while transforming equations from one coordinate system to another, which is routinely done in various branches of Physics.
CO 2	Students will learn about basic tensor algebra, covariant- and contra-variant tensors.
CO 3	Students will be familiar with Fourier series and apply the learned concepts to some well known examples.
CO 4	The course will help in understanding the integral transforms (Laplace and Fourier). Students will learn their use in solving differential equations by evaluating the inverse transforms also.
CO 5	Students will learn the basics of Green's function and how it is used to solve inhomogeneous differential equations.
CO 6	Students will be familiar with various special functions, solve corresponding differential equations and learn about their properties.

Syllabus

Vector Calculus & Tensors: Curvilinear coordinates, differential vector operators in curvilinear coordinates, spherical and cylindrical systems, general coordinate transformation, tensors; covariant, contravariant and mixed, algebraic operations on tensors.
Complex Analysis: The Cauchy-Riemann conditions, Cauchy integral theorem, Cauchy integral formula, Taylor and Laurent series, singularities and residues, Cauchy residue theorem, Calculation of real integrals.
Fourier Series: The Dirichlet conditions, The Fourier coefficients, Discontinuous functions, Non-periodic functions, Complex Fourier series, Parseval's theorem.
Integral transforms: Definitions, Conditions of existence, functions of exponential orders, Laplace transform of elementary functions, Basic theorems of Laplace transforms, Laplace transform of special functions, Inverse Laplace transforms, its properties and related theorems, convolution theorem, use of Laplace transforms in the solution of deferential equation with constant and variable coefficients and simultaneous differential equations, Fourier transform, Dirac delta function, Properties of Fourier transforms, Convolution and deconvolution, Parseval's theorem.

Green's Function: Green's functions and solutions to inhomogeneous differential equations and applications.
Special Functions: Beta and gamma functions, the exponential integral and related functions, Bessel functions of the first and second kind, Legendre and associated Legendre equations, Hermite equation, Laguerre and associated Laguerre equations.

Books Recommended:

1. "Mathematical methods for physicists", Arfken, Weber and Harris, Academic press.
2. "Mathematical methods for physics and engineering", Riley, Hobson and Bence, Cambridge University Press.
3. "Elements of group theory for physicists", A W Joshi, New Age International Publishers.
4. Harvil and Pipes L.A "Mathematical Methods for Physicists and Engineers" Tata McGraw-Hill Publishing Company, New Delhi.
5. Speigal M.R. "Laplace Transforms", Schaum Series Tata McGraw-Hill Publishing Company, New Delhi, 1981.
6. Kreyszig E. "Advanced Engineering Mathematics", John Wiley & Sons, New York, 2001.

Course code	PH-513
Course title	Electronics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
This course provides the student with the fundamental skills to understand the basic of semiconductor and components like diode, transistor, FET, MOSFET and operational amplifier It will build mathematical and numerical background for design of electronics circuit & component value. Students equipped with the knowledge and training provided in the course will be able to participate in design, development and operation in the different area of electronics system.

Course Outcomes: After completing the course students will

CO 1	understand the basics of semiconductor & devices and their applications in different areas.
CO 2	know the different biasing techniques to operate transistor , FET , MOSFET and operational amplifier in different modes.
CO 3	Analyze output in different operating modes of different semiconductor devices.
CO 4	be able compare design issues, advantages, disadvantages and limitations of basic electronics.

Syllabus

Electronic Devices: MESFETs and MOSFETs, Unijunction transistor (UJT), Four layer (PNPN) devices, Construction and working of PNPN diode, Semiconductor controlled rectifier (SCR) and Thyristor.

Electronic Circuits: Multivibrators (Bistable, Monostable, Astable), Differential amplifier, Operational amplifier (OP-AMP), OP-AMP as inverting, Non-inverting, Scalar, Summer, Integrator, Differentiator, Schmitt trigger and Logarithmic amplifier, Electronic analog computation circuit.

Communication Systems: Basic concepts of communication systems, Need for modulation, Information in communication system, Coding, Types of Pulse modulation, Pulse width modulation (PWM), Pulse position Modulation (PPM), Principle of Pulse code modulation (PCM).

Fiber Optics: Modes and configurations, Numerical Aperture, Optical sources – LED's and Lasers, Coupling sources to fibers, Optical detectors – p-i-n and APD detectors, Passive Optical components.

Microwave Devices: Principal and working of Gunn diode, IMPATT diode, Operation of Klystrons, Reflex klystrons and Magnetron.

Books Recommended:

1. Millman and Halkias "Electronic Devices and circuits"
2. Streetman Ben G and Banerjee "Solid State Electronic Devices", 5th Ed., Prentice Hall of India Ltd, New Delhi, 2004.
3. Sze S M. "Physics of Semiconductors Devices", John Wiley and sons, New Delhi.
4. George Kennedy "Electronic Communication Systems", 3rd Ed., Tata McGraw Hill Publishing Company, New Delhi, 1984.
5. Liao S.Y. "Microwave Devices and Circuits", Prentice Hall of India, New Delhi, 1995.
6. Mithal G.K. "Electronic Devices and Circuits", Khanna Publishers, Delhi, 1998.
7. Fiber Optics by Stewart D. Personick, Khanna Publisher.
8. Optical Fiber Communication by Gerd Keiser, McGraw Hill.

Course code	PH-514
Course title	Computational Techniques
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Computational Techniques is to enable the students to understand the basic of Fortran programming language and learn about different numerical methods useful in the field of research.

Course Outcome:-After completing the course students will be

CO 1	able to use Fortran programming to prepare program codes for different numerical methods
CO 2	learning different numerical methods for solving non-linear and linear system of equations
CO 3	able to use curve fitting methods for example interpolation, least square fitting and cublic splines
CO 4	able to solve integration and differentiation problems numerically
CO 5	learning numerical methods to solve differential equations

Syllabus

Programming (FORTRAN): Representation of integers, reals, characters, constant and variables, arithmetic expressions and their evaluation using rules of hierarchy. Assignment statements, Logical constants variables and expression, control structures, sequencing alternation, arrays, Manipulating vectors and matrices, Subroutines, I/O Statements

Roots of Equations: Non-linear equation: Approximate values of roots, Bisection Method, Regula-Falsi Method, Newton-Raphson method, Bairstow Method, Solution of set of non-linear equations.
Solution of Simultaneous Linear equation: Direct Method: Gauss elimination, Pivoting, Gauss-Jordon method, Matrix inversion. Iterative methods: Jacobi iteration method, Gauss Seidel iteration method.

Interpolation: Interpolation, Newton’s formula for forward and backward interpolation, Divided difference, Symmetry of divided differences, Newton’s general interpolation formula, Lagrange’s interpolation formula, Cubic splines, Least square approximation, Interpolation in multidimension.

Numerical Differentiation and Integration: Derivatives using forward and backward difference formula Numerical integration, A general quadrature formula for equidistant ordinates, Trapezoidal rule, Simpson’s rule, Weddle’s rule, Romberg integration, Gauss quadrature formula, multiple integrals.

Differential Equation: Ordinary differential equation: Euler's method, Modified Euler's method, Runge-Kutta Method, system of coupled first order ordinary differential equations. Partial differential equations: An elementary idea about numerical solution of partial differential equations using finite difference method.

Books Recommended:

1. Rajaraman V,"Computer Programming in Fortran-90 and 95", Prentice Hall of India Ltd., New Delhi.
2. Stephen J. Chapman," Fortran 90/95 for Scientists and Engineers", McGraw Hill Education
3. William Press, "Numerical Recipes in Fortran", Cambridge University Press India Pvt Ltd.
4. Joe D. Hoffman, "Numerical methods for scientist and engineers", Marcel Dekker Inc, New York
5. Steven C Chapra, Raymond P Canale "Numerical Methods for Engineers", Tata McGraw-Hill Education
6. Srimanta Pal "Numerical Methods: Principles, Analysis, And Algorithms", Oxford University Press
7. Scarbrough James B "Numerical Mathematical Analysis", Oxford and IBH Publishing Company, New Delhi, (1966).
8. Conte S.D. "Elementary Numerical Analysis", Tata McGraw Hill Publishing Company, New Delhi.

Course code	PH-515
Course title	Quantum Mechanics-I
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Quantum Mechanics-I is to enable the students to understand the basic techniques & methods of quantum mechanics so that they may apply these methods in various other fields of physical science and in research and development. Student will be made familiar with, different formalism of quantum mechanics, approximate methods and angular momentum algebra.

Course Outcome:-After completing the course students will be

CO 1	learning about meaning and significance of Hilbert space in quantum mechanics. They will be able to use Dirac picture of quantum mechanics.
CO 2	able to use different types of operators in quantum mechanics
CO 3	able to determine and apply commutation relations for different operators
CO 4	learning the postulated of quantum mechanics and how measurements are carried out.
CO 5	learning about the difference between Schrödinger and Heisenberg picture
CO 6	able to apply matrix method to solve Harmonic oscillator problem and will have knowledge about symmetries and cosnservation laws
CO 7	able to apply orbital angular momentum and spin angular momentum theory and will be able to calculate CG coefficients
CO 8	learning the difference between identical and non-identical particles. They will be able to write the symmetric and antisymmetric wave functions.
CO 9	able to apply variational methods and WKB methods for basic quantum mechanical problems

Syllabus

Linear Vector Space and Matrix Mechanics: Vector spaces, Dirac's bra and ket notation, Schwarz inequality, Orthonormal basis, Schmidt orthonormalisation method; Operators, Hermitian and Unitary operators, Projection operator, commutators, functions of operators, Eigenvalue and Eigenvectors, Simultaneous eigenvectors, infinitesimal and finite unitary transformations; Representation in discrete basis and in continuous basis; Postulates of quantum mechanics, uncertainty relation, Time development of states and operators, Heisenberg and Schrodinger representations; Symmetries and conservation laws, time translation and spatial translation, parity and time reversal; Harmonic oscillator in matrix mechanics.

Angular Momentum: Solution of the Schrodinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigenvalues and eigenvectors of L^2 and L_z. Spin angular momentum, General angular momentum, Eigenvalues and eigenvectors of J^2 and J_z. Representation of general angular momentum operator, Rotations in quantum mechanics; Addition of angular momenta, C.G. coefficients; Wigner Eckart theorem.

Identical Particles: Many particle system: interchange symmetry, system of distinguishable and non-interacting particles; System of identical particles: exchange degeneracy, symmetrization postulate, constructing symmetric and antisymmetric functions.

Stationary State Approximate Methods: Variational method with application to the ground states of harmonic oscillator, Hydrogen atom, Helium atom; WKB method: Bound states for potential with and without rigid walls, tunnelling through the barrier.

Books Recommended:

1. Sakurai J.J. "Modern Quantum Mechanics", Pearson Education Pvt. Ltd., New Delhi, 2002.
2. Nouredine Zetttili, "Quantum Mechanics: Concepts and Applications", Wiley, 2009
3. David J Griffiths, "Introduction to Quantum Mechanics", Pearson, 2014.
4. Mathews P.M. and Venkatesan K. "A Text Book of Quantum Mechanics", Tata McGraw-Hill Publishing Company, New Delhi, 1981.
5. Thankappan V.K. "Quantum Mechanics", Wiley Eastern, New Delhi, 1985.
6. Powell J.L. and Crasemann B "Quantum Mechanics", Narosa Publishing House, New Delhi.
7. Merzbaber E. "Quantum Mechanics", John Wiley & Sons, Inc., New York, 1970.
8. Devanathan V, "Angular Momentum Techniques in Quantum Mechanics", Springer .
9. Rose M E, "Elementary Theory of Angular Momentum", Dover Publications Inc. (2011)
10. Bransdan BH, Joachain CJ, "Quantum Mechanics", Perasons, 2nd Edition (2000)
11. Mcintyre D, "Quantum Mechanics", Pearsons, 1st Edition (2012)

Course code	PH-516
Course title	Solid State Physics- I
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The main objective of this course is to provide the fundamental knowledge in solid state physics and then study their physical properties. It covers crystal structures, binding and their defects, elastic properties, effect of temperatures on metals, basic of dielectrics, semiconductor phenomena and magnetic field effects.

Course Outcomes: After completing the course students will

CO 1	understand the basics of crystal structures, symmetry operations, determination of crystal structure and their applications in different areas.
CO 2	Detail of existing defects and their role in diffusion process
CO 3	be able to understand the elastic behavior under stress and elastic constants.
CO 4	understand the semiconductors, electron-hole process, magnetic field effect on semiconductors, metals.
CO5	understand the molecular interaction process and effect of electric field in dielectric materials

Syllabus

Crystal structure and bonding in solids: Bravais lattice, lattice planes and miller indices, reciprocal lattice, Diffraction conditions, Brillouin zones, Atomic Structure factor; types of crystal binding, cohesive energy of ionic crystals.

Defects and Diffusion in solids

Point defects: Schottky and Frenkel vacancies, Diffusion, Fick's law. Color centers, *F*-centers. Line defects (dislocation): Edge and Screw dislocation, Burger's vector, Slip, Planar (stacking) faults: Grain boundaries: Low angle grain boundaries.

Elastic Properties

Introduction, Analysis of Stress- strain relations, Elastic Compliance and Stiffness Constants, Elastic Waves in Cubic Crystals.

Thermal Properties: Phonon heat capacity, Density of states, Debye and Einstein theory of specific heat, Lattice Thermal Conductivity and Umklapp Processes, specific heat of metals.

Semiconductors: Direct and Indirect Absorption Processes, Equations of motion, effective mass, intrinsic carrier concentration, impurity conductivity, Cyclotron resonance and Magnetoresistance in semiconductors.

Fermi Surfaces and Metals: Zone schemes, Fermi surfaces; Hall Effect, Electron, Hole and Open orbits, Quantization of orbits in a magnetic field, the de Hass-van Alphen Effect, External orbits.

Dielectrics: Macroscopic field, The local field, Lorentz field, The Clausius- Mossotti relation, different contributions to polarization: dipolar, electronic and ionic polarizabilities.

Books Recommended :

7. Kittle C "Introduction to Solid State Physics", John Wiley & Sons, 2005.
8. Dekkar A J "Solid State Physics", Macmillan India Ltd., New Delhi, 2004.
9. Azaroff L V "Introduction to Solids", Tata McGraw-Hill Publishing Company, New Delhi, 1992.
10. Ashcroft N W and Mermin N D "Solid State Physics", Thomson Asia Pte. Ltd., 2006.
5. Singh, R.J., Solid State Physics, Pearson, Press, 2012.

Course code	PH-517
Course title	Atomic & Molecular Spectroscopy
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Quantum mechanics - I PH-515, Quantum mechanics - II PH-519
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Atomic and Molecular Spectroscopy is to enable the students to understand the basic techniques & methods of the subject so that they may apply these methods in various fields of research and development.

Course Outcomes: After the completion of this course students will achieve the ability to:

CO 1	Develop a basic understanding of Hydrogen atom orbitals and spectrum.
CO 2	Describe the respective spectra of atoms containing one and two optical electrons.
CO 3	Explain the change in behavior of atoms in external applied electric and magnetic field.
CO 4	Explain rotational, vibrational, electronic and Raman spectra of molecules.
CO 5	Describe electron spin and nuclear magnetic resonance spectroscopy and their applications.
CO 6	Understand the importance and practical application of spectroscopy in modern research.

Syllabus

Quantum States of One Electron Atom: Spin orbit interaction, fine structure of hydrogen, Lamb shift. One-electron atoms: Energy eigenvalues, wave functions, probability density, selection rules, quantum defect and penetrating & non-penetrating orbits, screening parameter, fine structure in the alkalis, intensity rules.

Coupling schemes: Equivalent and non-equivalent electrons, LS-coupling scheme, Hund's rules, fine structure, jj-coupling scheme, intermediate coupling.

Two Electron Systems: General characteristics of the energy levels of alkaline earth elements; selection rules and intensity rules, Interaction energy in LS coupling. Normal and Anomalous Zeeman effect-Paschen Back effect.

Breadth of spectral lines and Hyperfine structure: Natural breadth, Doppler effect and external effects. Doppler free spectroscopy. Hyperfine structure (qualitative), nuclear spin and isotope shift.

Molecular Structure: Types of molecules-Diatomic linear symmetric top, asymmetric top and spherical top molecules-Rotational Spectra of diatomic molecules as a rigid rotator-Energy levels and spectra of non rigid rotor-intensity of rotational lines. Vibrational energy of diatomic molecule as a simple harmonic oscillator – Energy levels and spectrum – Morse potential energy curve-Molecules as vibrating rotator – Vibration spectrum of diatomic molecule – PQR branches IR spectrometer (qualitative).

Spectroscopy: Raman effect – Quantum theory- Molecular polarisability – Pure rotational spectra of diatomic molecules – Vibration rotation Raman spectrum of diatomic molecules. Application of IR and Raman spectroscopy in the structure determination of simple molecules. Born Oppenheimer approximation – Franck Condon principle – dissociation and pre-dissociation – Dissociation energy.

Developments and applications: Terahertz spectroscopy and applications. Laser cooling: slowing an atomic beam, Doppler cooling, sub-doppler cooling, Sisyphus cooling, sub-recoil cooling. Trapping: Optical dipole traps, magnetic traps and evaporative cooling, magneto-optical trap. Magnetic resonance: exact resonance, general solution. Nuclear magnetic resonance, NMR in bulk samples, chemical shifts. Electron spin resonance.

Books Recommended:

1. Physics of atoms and molecules, Bransden & Joachain, Pearson.
2. Atomic Physics, C. J. Foot, Oxford University Press.
3. Introduction to Atomic Spectra, H.E. White, Mcgraw Hill.
4. Fundamentals of molecular spectroscopy, C.B. Banwell, E.M. McCash, Mcgraw Hill.
5. Spectra of diatomic molecules, Herzberg, D Van Nostrand Company.
6. Spectra of atoms and molecules, P.F. Bermath, Oxford University Press.
7. Atomic and Molecular Spectroscopy, S Svanber, Springer.

Course code	PH-518
Course title	Electrodynamics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Classical Mechanics PH-511, Mathematical Physics PH-512
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The course will enable the students to understand various laws of Electrostatics and Magnetostatics including boundary value problems. Maxwell Equations for understanding propagation of electromagnetic waves in various media. It will also help the student to understand the origin of the electromagnetic radiations from an accelerating charge particle.

Course Outcomes: After the completion of this course students will learn

CO 1	Fundamentals and applications of various laws of electricity and magnetism.
CO 2	To solve Maxwell equations in free space and for harmonically varying fields.
CO 3	About the potential formulation of Maxwell's equations.
CO 4	To solve Electromagnetic wave equations in conducting as well as in non-conducting media.
CO 5	To determine energy carried by EM waves and to derive Poynting theorem.
CO 6	Interaction of electromagnetic waves with matter.
CO 7	About the fields of an accelerating charge.

Syllabus

Electrostatics: Introduction, Work and Energy in electrostatics, Polarization, Laws of electrostatic field in the presence of dielectrics, Energy of the field in the presence of a dielectric, Boundary condition, Poisson and Laplace equations, Earnshaw's theorem, Boundary conditions and Uniqueness theorem, Multipole expansion, Method of electrostatic images.
Magnetostatics: Introduction, Laws of magnetostatics, Magnetic scalar and vector potentials, Magnetic media, magnetization, magnetic field vector, Boundary conditions.

Time Varying Fields: Maxwell's equations, Displacement current, Electromagnetic potential, vector and scalar potential, Gauge transformations; Lorentz and Coulomb Gauge, Poynting theorem, conservation laws for a system of charged particles and electromagnetic field, continuity equation.

Electromagnetic Waves: Plane waves in Non-conducting and conducting media Polarization-linear and circular polarization. Skin effect, Reflection and refraction of electromagnetic waves across a dielectrics interface at a plane surface between dielectrics. Total internal reflection, Polarization by reflection, Reflection from the surface of a metal.

Electromagnetic Radiation: Retarded Potentials, Radiation from an oscillating Dipole, Lienard-Wiechert Potentials, Potentials for a charge in uniform motion-Lorentz Formula, Fields of an accelerated charge.

Books Recommended:

1. Jackson J.D. "Classical Electrodynamics", John Wiley & Sons Pvt. Ltd., New York, 2004.
2. Griffiths D.J." Introduction to Electrodynamics", Pearson Education Pvt. Ltd., New Delhi, 2002.
3. Marian J.B and Heald M.A. "Classical Electromagnetic Radiation", Academic Press, New Delhi,
4. Puri S.P. "Classical Electrodynamics", Tata McGraw-Hill Publishing Company, New Delhi.
5. Jordon E.C. and Balmain K.G. "Electromagnetic Waves and Radiating Systems", Prentice Hall of India, New Delhi, 1995.

Course code	PH-519
Course title	Quantum Mechanics-II
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Quantum Mechanics-I PH-515
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Quantum Mechanics-II is to enable the students to understand the basic techniques & methods of quantum mechanics so that they may apply these methods in various fields of research and development. Student will be made familiar with, scattering theory, perturbation theory and relativistic quantum mechanics.

Course Outcome:-After completing the course students will be

CO 1	learning how scattering amplitude and scattering cross-section are related to each other
CO 2	able to find scattering cross-section using partial wave analysis and Born approximation techniques
CO 3	knowing the non-degenerate and degenerate perturbation theory and their applicability
CO 4	able to use Fermi Golden rule to find transition amplitude
CO 5	learning the need of relativistic quantum mechanics
CO 6	learning the Klien Gordon equation and its limitations
CO 7	learning the Dirac equation and how to use it to study fine structure of hydrogen atom.

Syllabus

Scattering Theory: Scattering Cross-Section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potential. Electron scattering by an atom. Optical theorem, Scattering of identical particles, S-matrix and its properties, Lippmann Schwinger equation.

Perturbation Theory: An introduction to perturbation theory; its relevance, and physical examples, Time-independent perturbation theory: non-degenerate case, Time-independent perturbation theory: degenerate case, Time- dependent perturbation theory;, atom- field interactions and the dipole approximation, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light; Adiabatic and Sudden Approximation.

Relativistic Quantum Mechanics: Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, The non-relativistic limit of Dirac equation, Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom.

Books Recommended:

1. Sakurai J.J. "Modern Quantum Mechanics", Pearson Education Pvt. Ltd., New Delhi, 2002.
2. Nouredine Zetttili, "Quantum Mechanics: Concepts and Applications", Wiley, 2009
3. David J Griffiths, "Introduction to Quantum Mechanics", Pearson, 2014.
4. Mathew P.M. and Venkatesan K. "A Text Book of Quantum Mechanics", Tata McGraw-Hill Publishing Company, New Delhi, 1981.
5. Thankappan V.K. "Quantum Mechanics", Wiley Eastern, New Delhi, 1985.
6. Ashok Das, "Lectures on Quantum Field Theory", World Scientific, 2008.
7. Mandel H. and Shaw G. "Quantum Field theory", Wiley Eastern, New Delhi, 1984.
8. Bransdan BH, Joachain CJ, "Quantum Mechanics", Perasons, 2nd Edition (2000)
9. Mcintyre D, "Quantum Mechanics", Pearsons, 1st Edition (2012)
10. Lahiri A and Pal PB, "A first book of Quantum Field Theory", Alpha Science Intl Ltd; 2nd edition (2005)

Course code	PH-520
Course title	Solid State Physics II
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Solid State Physics-I PH-516
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on solid state physics (II) is to enable the students to understand the physics of magnetic and superconducting, ferro & antiferromagnetic materials and behaviour of these materials under temperature and external fields. Students may also able to understand the optical behaviour of materials and various ordered phases of matters. The study of this course enables the students to extend his knowledge for research work in the condensed matter physics and material science.

Course Outcomes: After completing the course students will

CO 1	understand the basics of magnetic materials, phenomena of dia, para and ferromagnetism and their properties
CO 2	able to understand the theory of ferroelectrics materials,transition temperatures and their potential applications.
CO 3	learn the behavior of materials below a certain temperature (superconducting materials) and high temperature superconductors.
CO 4	understand the different ordered phase of matters
CO5	understand the basic of liquid crystals, various phases and use of LCs in displays.

Syllabus

Dia-, Para- and Ferro-magnetism: Classification of magnetic materials, the origin of permanent magnetic dipoles, diamagnetic susceptibility, Langevin's classical theory of diamagnetism; Classical theory of Para magnetism, Quantum theory of Para magnetism, Quenching of orbital angular momentum, Cooling by adiabatic demagnetization, Paramagnetic susceptibility of conduction electrons; Ferromagnetism, Spontaneous magnetization in ferromagnetism, The Weiss molecular field, The interaction of the Weiss field, Ferromagnetic domains, Bloch wall, Spin waves, Quantization of spin waves, Thermal excitations of magnons.

Antiferro and Ferri-magnetism

The two sub lattice model, exchange interaction, Neel's Temperature; Structure of ferrites, Saturation magnetization, Neel's theory of ferrimagnetism, Curie temperature and susceptibility of ferrimagnets

Superconductivity

Superconductivity, zero resistivity, critical temperature, Meissner effect, Type I and Type II superconductors, specific heat and thermal conductivity, London Equations, BCS theory, Ginzburg-Landau theory, Josephson effect: dc Josephson effect, a c Josephson effect, macroscopic quantum interference, High temperature superconductivity (elementary).

Ferro-electrics: General properties of ferroelectric materials. The dipole theory of ferroelectricity, objection against dipole theory, Pizo and pyroelectrics (elementary idea)

Optical properties: Optical constants and their physical significance, Kramer-Kroning relations, Electronic interband transitions, Frenkel and Mott-Wannier excitons.

Ordered phases of matter: Translational and orientational order, Liquid crystal phases; nematic, smectic, cholestric, Landau Theory of isotropic- nematic phase transitions, Physics of LCD devices, Quasi crystals

Books Recommended:

1. Kittle C "Introduction to Solid State Physics", John Wiley & Sons, 2005.
2. Dekkar A J "Solid State Physics", Macmillan India Ltd., New Delhi, 2004.
3. Ashcroft N W and Mermin N D "Solid State Physics", Thomson Asia Pte. Ltd., 2006
4. Omar M Ali, "Elementary solid state physics, Principles and applications", Pearson Press, 2011
5. Hamley Ian W, "Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials", John Wiley, 2007
6. Colling P J , "Liquid Crystals", Princeton Univ. Press, Second Edition, 2002

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Course code	PH-521
Course title	Plasma Physics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Electrodynamics PH-518
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The course will enable the students to understand the fundamental properties and physical processes that govern plasma relevant to space physics, laboratory experiments, controlled fusion and industry. This course will well equip the students to pursue their career in plasma science and technology as it encompasses immense diversity, pervasiveness and potential.

Course Outcome:- After completing the course students will learn

CO 1	basics of Plasma physics
CO 2	single particle motion in electric and magnetic fields and magnetic mirror
CO 3	applications of Plasma
CO 4	various Plasma waves
CO 5	the non-linear effects in Plasma
CO 6	the fundamentals of inertial confinement fusion and magnetic confinement fusion and their role in future energy production

Syllabus

Basics of Plasmas: Occurrence of Plasma in nature, Definition of plasma, Concept of temperature, Debye shielding and plasma parameter, Single particle motions in uniform E and B fields, Non uniform magnetic field, grad – B drift and curvature drift, Magnetic mirror. Simple applications of plasmas.

Plasma Waves : Plasma oscillations, Electron plasma waves, Ion waves, Electrostatic electron and ion oscillations perpendicular to magnetic field, Upper hybrid waves, Lower hybrid waves, ion cyclotron waves, Light waves in plasma.

Non-linear Effects in Plasma: Introduction, Ponderomotive force, Parametric Instabilities: Coupled Oscillators, Frequency matching, Instability Threshold, Oscillating two-stream instability.

Nuclear Fusion: Introduction, Lawson criteria, Fundamentals of inertial confinement fusion, Fundamentals of magnetic confinement method, Tokamak, Hydrodynamics of implosion.

Books Recommended:

1. Chen F F "Introduction to Plasma Physics and Controlled Fusion", Plenum Press, New York, 1980.
2. Krall N.A. and Trivelpiece A.W. "Principle of Plasma Physics", Tata McGraw- Hill Publishing Company, New Delhi, 1972.
3. Dendy R "Plasma Physics", Cambridge University Press, New York, 1996.
4. Friedberg J P "Ideal Magnetohydrodynamics"
5. Seshadri S R "Fundamental of Plasma Physics",
6. Chanchal Uberoi "Introduction to Unmagnetized Plasma", Prentice Hall of India Pvt. Ltd., New Delhi, 1997

Course code	PH-522
Course title	Nuclear Physics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Quantum Mechanics-I PH 515, Quantum Mechanics-II PH 519
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim and objective of the course on Nuclear Physics is to enable the M.Sc. students to understand the basic concepts of static properties of nuclei, radioactive decays, nuclear forces, nuclear reactions, radiation interaction.

Course Outcome:- After completing the course students will be able to

CO 1	understand the nuclear forces & nuclear properties**.**
CO 2	get knowledge about the hyperfine structure & nuclear model like; Fermi gas model, Liquid drop model, Shell Model, Single particle shell model, Magic numbers, Collective nuclear model, rotational and vibrational spectra
CO 3	learn about the radioactive decays like α-particle emission, beta decays and gamma decay. Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism.
CO 4	get knowledge about the nuclear reactions and their properties, Compound nuclear-scattering matrix, Resonance scattering.

Syllabus

Nuclear Properties: Introduction, constituents of nucleus and their intrinsic properties, angular momentum, magnetic moment and electric quadrupole moment of nucleus, wave mechanical properties of nucleus, nuclear forces

Nuclear Interactions: Nuclear force: Two nucleon system**,** deuteron problem, binding energy, nuclear potential well, pp and pn scattering experiments at low energy, meson theory of nuclear force, e.g. Bartlett, Heisenberg, Majorana forces and potentials, exchange forces and tensor forces, effective range theory-spin dependence of nuclear force, Charge independence and charge symmetry of nuclear forces-Isospin formalism, Yukawa interaction

Nuclear Models: Liquid drop model, Bohr-Wheeler theory of fission, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Applications of Shell model like Angular momenta and parities of nuclear ground states, Quantitative discussion and estimates of transition rates, magnetic moments and Schmidt lines, Collective model-nuclear vibrations spectra and rotational spectra

Nuclear Decay: Beta decay, Fermi theory of beta decay, shape of the beta spectrum, Total decay rate, Angular momentum and parity selection rules, Comparative half-lives, Allowed and forbidden transitions, selection rules, parity violation, Two component of neutrino decay, Detection and properties of neutrino, Gamma decay, Multipole transitions in nuclei, Angular momentum and parity selection rules, Internal conversion, Nuclear isomerism.

Nuclear Reaction: Conservation laws, energetics of nuclear reaction, Direct and compound nuclear reaction mechanism, Compound nuclear-scattering matrix, Reciprocity theorem, Breit Wigner one level formula, Resonance scattering.

Books Recommended:

1. Bohr A. and Mottelson B.R. "Nuclear Structure", Vol. 1 (1969) and Vol.2 (1975), Benjamin, Readings, A.
2. Krane K. S. "Introductory Nuclear Physics", Wiley Estern, New York, 1988.
3. Roy R.R. & Nigam B.P. "Nuclear Physics", New Age International, New Delhi.
4. Irving Kaplan "Nuclear Physics", Addison Wesley, New Delhi.
5. Pal M. K. "Theory of Nuclear Structure", East West Press Pvt. Ltd., New Delhi.
6. Hans H.S. "Nuclear Physics: Experimental and Theory", New Age International, New Delhi.
7. Ghoshal S. N "Nuclear Physics", S. Chand and Company, Delhi

Course code	PH-523
Course title	Particle Physics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Quantum mechanics - I PH-515, Quantum mechanics - II PH-519
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Particle Physics is to enable the students to understand the elementary particles and basic ideas about the interactions and fields so that they can use them to understand the Standard Model. Students will be made familiar with Spontaneous breaking of symmetry and Goldstone theorems.

Course Outcome:-After completing the course students will be

CO 1	learning the types of basic interactions and invariance principles
CO 2	quantum numbers including Parity, Isospin, G-parity
CO 3	form factors in the electromagnetic interactions
CO 4	basics of strong interactions and quark model
CO 5	V-A weak interaction theory and Cabbibo theorem
CO 6	global and local invariance of the Action, Noether's theorem
CO 7	Spontaneous breaking of symmetry and Goldstone theorem. Abelian and Non-Abelian gauge fields

Syllabus

Introduction and Overview: Historical development, Particle classification: Bosons, Fermions, Particles and Antiparticles, Quarks and Leptons; Basic ideas about the interactions and fields in Particle Physics, Types of interactions: Electromagnetic, Weak, Strong and Gravitational, Natural System of Units in High Energy Physics.

Invariance Principles and Conservation laws: Conservation of electric charge, Baryon number, Lepton number, Continuous symmetry transformations: translation and rotation; Parity, Pion parity, Charge conjugation, Strangeness and Isospin, Two Nucleon System, Pion-Nucleon System, G-parity, Time reversal invariance, Associated production of particles and Gell-Mann Nishijima scheme, $K^0 - \underline{K}^0$ doublet, CP violation in K- decay, CPT theorem
.
Electromagnetic Interactions. Form factors of nucleons. Parton model and Deep inelastic scattering structure functions, Cross Section and Decay Rates.

QCD and Quark model: Asymptotic freedom and Infrared slavery, confinement hypothesis. Classification of hadrons by flavor symmetry : SU(2) and SU(3) multiplets of Mesons and Baryons. The Baryon Octet and Decuplet, Pseudoscalar mesons and Vector mesons.

Weak interactions: Classification of weak processes, Fermi theory of β- decay, Parity non conservation in β - decay, two component theory of neutrino and determination of helicity, V-A interaction, Strangeness changing and non-changing decays, Cabibbo's theory.

Gauge invariance and Unification schemes: Global and Local invariance of the Action, Noether's theorem, Spontaneous breaking of symmetry and Goldstone theorem. Abelian and Non-Abelian gauge fields.

Books Recommended:

1. Introduction to High Energy Physics, D.H. Perkins.
2. Introduction to Particle Physics, M.P. Khanna.
3. Introduction to Elementary Particles, D. Griffiths.
4. Particle Physics, Martin and Shaw.
5. Introduction to Quarks and Partons, F.E. Close
6. Quarks and Leptons: An Introductory Course in Modern Particle Physics, F. Halzen and A.D. Martin.

Course code	PH-524
Course title	Statistical Physics
Credits	3-1-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course "Statistical Physics" is to train the students in the methods of Statistical Physics. They will learn the various fundamentals and applications of classical and quantum statistical methods and phase transition theory.

Course Outcomes: Following are the outcomes of the course:

CO 1	Students will learn some important results of thermodynamics, thermodynamical potentials and relations
CO 2	Students will learn the fundamentals of classical statistical mechanics. They will learn about phase space, various ensembles and their application in some cases.
CO 3	Students will learn about the quantum mechanical theory of statistics and its application in various important cases of Bosons and Fermions.
CO 4	The course will help students in studying the behaviour of ideal Bose and Fermi gases.
CO 5	Students will be familiar with the theory of phase transition and critical phenomenon.

Syllabus

Review of Thermodynamics: Extensive and intensive variables, Laws of thermodynamics and their consequences, Thermodynamic potentials, Maxwell's thermodynamical relations

Classical Statistical Mechanics: The macroscopic and microscopic states, Postulate of equal a priori probability, contact between statistics and thermodynamics, classical ideal gas, Gibbs' paradox, phase space and Liouville's theorem and its consequences, Microcanonical, canonical, and grand canonical ensembles, partition functions, fluctuation of energy and density, Equipartition and virial theorems, Derivation of thermodynamic properties; some examples including (i) Classical ideal gas (ii) system of classical harmonic oscillators

Quantum Statistical Mechanics: Quantum-mechanical ensemble theory: Density matrix, simple applications of density matrix. Symmetric and Antisymmetric Wavefunctions. Microcanonical ensemble of ideal Bose, Fermi and Boltzmann gases. Statistics of the occupation numbers

Ideal Bose and Fermi Systems: Thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, Blackbody radiation and Plancks law of radiation, Thermodynamic behaviour of an ideal Fermi gas, Magnetic behavior of an ideal Fermi gas, Pauli paramagnetism

Phase Transition and critical phenomenon: First and second order phase transitions, Ising model, Critical exponents, Landau theory of phase transitions.

Books Recommended:

1. Patharia R.K. “Statistical Mechanics”, Pergamon, Oxford.
2. Kerson Huang “Statistical Mechanics”, Wiley Eastern, New Delhi.
3. Kittel C. “Elementary Statistical Physics”, Wiley Eastern, New Delhi.
4. Agarwal B.K. and Eisner M “Statistical Mechanics”, Wiley Eastern, New Delhi.
5. Chandler D. “Introduction to Modern Statistical Mechanics”, Oxford University Press, New Delhi

Laboratory Courses

Course code	PH-541
Course title	Electronics Laboratory
Credits	0-0-3
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
This course provides the student with the practical skills to understand the basic of semiconductor and components like diode, transistor, FET, MOSFET and operational amplifier. Students equipped with the knowledge and training provided in the course will be able to participate in design, development and operation in the different area of electronics system.

Course Outcome:-

CO 1	To study basics of semiconductor & devices and their applications in different areas.
CO 2	To study different biasing techniques to operate transistor , FET , MOSFET and operational amplifier in different modes.
CO 3	Analyze output in different operating modes of different semiconductor devices.
CO 4	Compare design issues, advantages, disadvantages and limitations of basic electronics.

Syllabus

List of Experiments:

1. Measurement of amplitude, frequency and phase of given signals using oscilloscope.
2. Study the characteristics of FET.
3. To study pulse amplitude, Pulse width and Pulse position modulations.
4. To study the frequency response of an operational amplifier.
5. To study use of operational amplifier for different mathematical operations.
6. To study the characteristics of inverting and non inverting operational amplifier.
7. To study the characteristics of multivibrators – bistable, Astable, monostable.
8. To determine the numerical aperture (NA) of a given multimode fiber.

9. To study a simple intensity modulated fiber-optic press;lkjure sensor.
10. To study the characteristics of klystron oscillator/amplifier.
11. To study the characteristics of GUNN oscillator.
12. Study of radiation pattern of a given planar antenna (microstrip).
13. Study the s-parameters of stripline base components and calculate its impedance.
14. To study the logic gates (IC trainer)

Course code	PH-542
Course title	Computer Laboratory
Credits	0-0-3
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Computer Laboratory is to enable the students to prepare codes for different numerical methods using Fortran programming language. This will be useful for research and development purpose.

Course Outcome:-Students will be able to prepare codes on

CO 1	non-linear and linear system of equations
CO 2	different interpolating methods and least square fitting
CO 3	numerically integrating methods
CO 4	first order differential equations

Syllabus

List of Experiments:

1. **Determination of Roots:**
   a) Bisection Method
   b) Newton Raphson Method
   c) Secant Method
   d) Coupled non-linear equations

2. **Matrix Manipulation:**
   a) Matrix Multiplication
   b) Determinant
   c) Gauss Elimination
   d) Matrix Inversion
   e) Gauss Jordan

3. **Interpolation:**
   a) Forward interpolation, Backward interpolation
   b) Lagrange's interpolation
   c) Least square method

4. **Integration:**
   a) Trapezoidal Rule
   b) Simpson 1/3 and Simpson 3/8 rules

c) Multiple integral

5. **Differential Equations:**

a) Euler's method
b) Runge Kutta Method
c) Coupled first order differential equations
d) Solution of partial differential equation

Course code	PH-543
Course title	Solid State Physics Laboratory
Credits	0-0-3
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of this course on Solid State Physics Lab is to enable the students to study the physical properties of different kind of materials and their behavior under external magnetic, electric fields and temperature. After performing these experiments students may have a better understanding of the solid state physics.

Course Outcome:- students may able to study

CO 1	the band gap, magneto resistance, resistivity and charge carrier concentration in semiconductors.
CO 2	various phases of liquid crystalline materials in heating/cooling process
CO 3	the phase transition temperature of liquid crystal materials using microscopy
CO4	dielectric permittivity of nematic/ferroelectric liquid crystals material
CO5	the optical behaviour of LC material in thin cell with temperature and voltae

List of Experiments:

1. To determine charge carrier density and Hall coefficient by Hall Effect.
2. To determine the band gap of a semiconductor using p-n junction diode.
3. To determine magnetic susceptibility of material using Quink's tube method.
4. To determine energy gap and resistivity of the semiconductor using four probe method.
5. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.
6. To find magneto resistance of semiconductor.
7. To determine dielectric constant of a material with Microwave set up.
8. Study the micro-textures and phase transition temperatures in liquid crystal cell.
9. Study the Curie temperature and dielectric constant of ferroelectric material.

10. Study the dielectric properties of ferroelectric/ nematic liquid crystalline material in planar cell configuration.

11. Study the voltage and temperature dependence behaviour on optical responses of liquid crystal using He-Neon laser

Course code	PH-544
Course title	Spectroscopy Laboratory
Credits	0-0-3
Course type	For M.Sc. (Physics) students

Prerequisites: Quantum Mechanics PH-515, Quantum Mechanics PH-519
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Spectroscopy Laboratory is to enable the students to understand the atomic structure and its relation to the production of light. To do this different spectrometers will be used to look at the color spectrum produced by different sources like sodium lamp, He-Ne laser etc.

Course Outcome:-Students will be able to understand and practically experience many quantum mechanical phenomenon like

CO 1	the presence of the discrete energy levels in the atoms.
CO 2	the understanding of the wave nature of light along-with the measurement of the wavelength of the light.
CO 3	the impact of the external magnetic field on the atomic energy levels (Zeeman Effect). This knowledge will then be used to determine the e/m ratio for the electron.
CO 4	the working experience with many modern spectroscopic techniques like Electron-Spin resonance.

Syllabus

List of Experiments:

1. To find the wavelength of monochromatic light using Febry-Perot interferometer.
2. Determination of e/m of electron by Normal Zeeman Effect using Febry-Perot interferometer.
3. To find the wavelength of sodium light using Michelson interferometer.
4. To calibrate the constant deviation spectrometer with white light and to find the wavelength of unknown monochromatic light.
5. To find the grating element of the given grating using He-Ne laser light.
6. To find the wavelength of He-Ne laser using Vernier calipers.
7. To study Faraday effect using He-Ne Laser.

8. To verify the existence of Bohr’s energy levels with Frank-Hertz experiments.

9. Determination of Ionization Potential of Lithium.

10. Determination of Lande’s factor of DPPH using Electron-Spin resonance (E.S.R.) Spectrometer.

11. To study the fluorescence spectrum of DCM dyes and to determine the quantum yield of fluorescence maxima and full width at half maxima for this dye using monochromator.

Course code	PH-545
Course title	Nuclear Physics Laboratory
Credits	0-0-3
Course type	For M.Sc. (Physics) students

Prerequisites: Quantum Mechanics PH-515, Quantum Mechanics PH-519
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
This course provides the student with the practical training of with different nuclear physics experimental set-ups mainly GM counter and scintillation counter

Course Outcome:-After completing the course students will

CO 1	have knowledge about characteristics of GM counter and how to use it for different applications
CO 2	have understanding of how to find Planck's constant using Photocell and Interference filters
CO 3	be knowing about use of scintillation counter applications

Syllabus

List of Experiments:

1. To study the characteristics of G.M. counter.
2. To determine the dead time of G.M. counter.
3. To study absorption of beta particles is matter.
4. To study Gaussian distribution using G.M. counter.
5. Source strength of a beta-source using G.M. counter.
6. Study of Poisson distribution.
7. To investigate the statistics of radioactive measurements.
8. Determination of Planck's constant using Photocell and Interference filters.
9. Recording and calibrating a gamma ray spectrum by scintillation counter.

10. To calibrate the scintillation counter using a known Gamma Source.

11. To study absorption of gamma radiation by scintillation counter.

12. Identifying and determining the activity of weakly radioactive samples.

13. Recording a beta spectrum using a scintillation counter.

14. Demonstrating the tracks of α- particles in a Wilson cloud chamber.

15. Rutherford scattering: measuring the scattering rate as a function of the scattering angle and the atomic number.

16. Study of nuclear magnetic resonance in polystyrene, glycerin and Teflon.

17. Quantitative observation of the Compton Effect.

18. Deflection of beta radiation in a magnetic field.

Course code	PH-546
Course title	Plasma Laboratory
Credits	0-0-3
Course type	For M.Sc. (Physics) students

Prerequisites: Electrodynamics PH-518
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
To measure various plasma parameters with the help of by using single and double Langmuir probe, to study the breakdown voltage of a given plasma, to obtain the plasma coating on a substrate and also cleaning of substrate surfaces, to launch and detect ion-acoustic waves, to understand the microwave plasma, to understand the conditions of occurrence of striations, basic understanding acquired will be helpful in industry as well as for doing experimental plasma research.

Course Outcome: Students will learn

CO 1	Measurement of floating potential, Plasma potential, electron potential and ion density.
CO 2	Importance of Paschen curve for determining the minimum value of breakdown voltage for Plasma formation.
CO 3	The physics of sputtering with and without magnetic field.
CO 4	The collective behavior of a plasma.
CO 5	The physics of microwave plasma.
CO 6	To find the range of current values, pressure and tube radii, where striations can survive.

Syllabus

List of Experiments:

1. Study of Plasma parameters such as Electron density, ion density, Electron temp, floating potential, Plasma Potential etc. by using Single and Double Langmuir probe.

2. Verification of Paschen curve.

3. Study of Plasma coating of different materials on substrate.

4. Study of Plasma cleaning of substrate surfaces.

5. Demonstration of microwave plasma.

6. Study of collective behavior of a plasma by launching and detecting ion acoustic waves.

7. To study the conditions of occurrence of striations

Elective Courses

Course code	PH-531
Course title	Nuclear Accelerator and Radiation Physics
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The course on Nuclear Accelerators and Radiation Physics enables the students to understand the nuclear radiation, neutron classification, neutron detection, and diffusion of thermal neutrons, nuclear detectors, different types of detectors, nuclear accelerators, and various types of accelerators, Nuclear reactors.

Course Outcome:-Students will be able to

CO 1	gain an understanding about nuclear radiations, their effect, and also their monitoring.
CO 2	study about Neutron classification, sources of neutrons, Neutron detectors etc.
CO 3	execute Radiation detection, Geiger-Muller counter and Scintillation detector in detail.
CO 4	understand about the various types of nuclear accelerators.
CO 5	know about Nuclear Reactors.
CO 6	know about the determination of nuclear properties**;** Nuclear mass measurement, Ion optics, Production and detection of positive ions.

Syllabus

Detection of Nuclear Radiations and their measurements: Methods for detection of free change carriers, Ionization chamber, Proportional counter, Geiger-Muller counter, Semiconductor detectors, Scintillation detector, Cherenkov detector, Wilson cloud chamber, Bubble chamber, Spark chamber, Nuclear emulsion techniques, Solid State nuclear track detector.

Determination of Nuclear Properties: Nuclear mass measurement, Ion optics, Production and detection of positive ions, Dempster's mass spectrometer, Aston's and Bainbridge's mass spectrograph, Double focusing mass spectroscope, Measurement of nuclear spin and magnetic moment, Nuclear spin from Zeeman effect of hyper fine lines, Nuclear spin and statistics from molecular spectra, Atomic beam method of nuclear magnetic moment determination, Magnetic resonance absorption method, Nuclear induction and microwave spectroscopy method.

Accelerators of Charged Particles: Classification and performance characteristics of accelerators, Ion sources, Electrostatics accelerators, Cockroft – Walton generator, Cyclotron, Synchro-cyclotron, Betatron, Electron and proton synchrotron, Microtron, Linear accelerator.

Neutrons and Neutron Physics: Classification and properties of neutron, Sources of neutron, Neutron detectors; Slow neutron detection through nuclear reactions and induced radioactivity, Fast neutron detection, Neutron monochromators, Diffusion of thermal neutron.

Books Recommended:

1. Lapp R E and Andrews H L "Nuclear Radiation Physics", Fourth edition, Prentice Hall, New Delhi, 1963.
2. Mc Dowell C A "Mass spectroscopy", McGraw Hill Book Company, New Delhi, 1963.
3. Segre E "Experimental Nuclear Physics", John Wiley and Sons, 1953.
4. Livingstone M.S. and Blewett J P "Particle Accelerators", McGraw Hill Book Co., 1962.
5. Kapoor S S and Ramamurthy V S "Nuclear Radiation Detectors" Wiley Eastern, New Delhi, 1986.
6. Glasstone S "Principles of Nuclear Reactor Engineering", Mc Millan Co. London, 1956.
7. Ghoshal S N "Nuclear Physics", S Chand and Co., New Delhi, 2016.

Course code	PH-532
Course title	Opto-electronics
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Solid state physics-I, Solid state physics-II
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Optoelectronics is introduce the field to the students. Students will learn about the fundamentals of various devices and their use.

Course Outcomes: Following will be the outcomes of the course:

CO 1	Students will learn about the modulation of light, various types of semiconductors, conduction mechanism and PN junction diode
CO 2	Students will learn about how the semiconductor materials are processed and how doping is achieved in them
CO 3	Students will be familiar with the fundamentals of luminescence and associated devices.
CO 4	Students will gain details understandig of various lasers, their working and their use in present day technology

Syllabus

Introduction : Light, elements of solid state physics, modulation of light, Review of Energy bands, effective mass, Fermi level, classification of semiconductors into element, binary, ternary and quaternary compounds, conduction mechanisms, amorphous semiconductors. Contact potential explanation based on band structure, M-S contact and its properties, barrier layer, P-N junction, potential barrier and barrier width, forward and reverse saturation current junction capacitance.

Processing of Semiconductor Materials: Purification, Zone refining and zone floating methods, Epitaxial growth methods, liquid phase, vapour phase and molecular beam epitaxy. Introduction of impurities, junction,successive doping method, epitaxial and diffusion methods, MESA and planar structure doping of amorphous semiconductors.

Displays devices and photo detectors: Luminescence from quantum well, photo luminescence and phosphorescence, phototransistors electro luminescence process, LED's their structures and choice of materials, Plasma displays, liquid crystal displays Introduction, thermal detector, photon devices and their characteristics, solar cells, photomultimeter

Laser: Emission and absorption of radiation, population inversion, pumping, doped laser, gas laser, semiconductor laser, liquid dye laser, laser modes and holography

Books Recommended:

1. S.M.Sze, "Physics of Semiconductor Devices", 2nd Ed., Wiley, New York,2000.
2. P.Bhattacharya, "Semiconductor Opto-electronic Devices", PHI, 1996.
2. J.Wilson & J.F.B.Hawkes, "Optoelectronics", PHI, 1998.
3. S.S. Islam, "Semiconductor Physics and Devices", Oxford University Press, 2005.
4. A. K. Ghatak & K Thyagarajan, "Optical Electronics", Cambridge University Press, 1989.

Course code	PH-533
Course title	Microwave Electronics
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Electronics PH-513
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Microwave Electronics is to introduce the students with the basics of microwave electronics and related applications.

Course Outcomes: After completing the course students will

CO 1	learn the applications of microwave and properties of different waveguides
CO 2	have understanding about the use microwave tubes for example Klystrons and Magnetrons
CO 3	have understanding about the working of IMPATT and TRAPATT, Transferred Electron Device.
CO 4	develop understanding about Parametric Amplifier and microwave amplifier

Syllabus

Introduction: Microwaves and its frequency spectrum, Application of microwaves, Waveguides - Rectangular wave guides, Circular wave guide, Wave equations & their solutions, TE, TM & TEM modes. Attenuation - Cause of attenuation in wave guides, wall current & derivation of attenuation constant, Q of the wave guide. Resonators - Resonant Modes of rectangular and cylindrical cavity resonators, Q of the cavity resonators, Excitation techniques, Introduction to Microstrip and Dielectric resonators. Microwave propagation in ferrites, Faraday rotation, Devices employing Faraday rotation (isolator,Gyrator,Circulator). Introduction to single crystal ferromagnetic resonators, YIG tuned solid state resonators.

Microwave tubes: Spacecharge spreading of an electron beam, Beam focusing, Klystrons - Velocity Modulation, Two Cavity Klystron, Reflex Klystron, Efficiency of Klystrons. Magnetrons - Modes of oscillation & operating characteristics, Traveling wave tubes.

Devices: Avalanche Transit Time Device - Read Diode, Negative resistance of an avalanching p-n Junction diode, IMPATT and TRAPATT, Transferred Electron Device - Gunn effect, two valley model, Different Modes for Microwave generation, Passive Devices - Termination (Short circuit and matched terminations) Attenuator, Phase changers, Tees, Hybrid Junctions, Directional coupler.

Parametric Amplifier: Varactor, Equation of Capacitance in Linearly graded & abrupt p-n junction, Parametric upconvertor, Negative resistance parametric amplifier, Noise in parametric amplifiers.

Microwave Antennas: Introduction to antenna parameters, Potential functions, Radiation from a aperture antenna, Electromagnetic Horns, Prabolic reflectors, Microstrip antenna, Introduction to antenna arrays.

Books Recommended:

1. Jorden & Balmain, "Electromagnetic waves & Radiating Systems", PHI, 1993.
2. Atwater, "Introduction to Microwave Theory", McGraw Hill, 1962.
1. M.L. Sisodia and G.S. Raghuvanshi, "Microwave Circuits & Passive Devices", New Age International, 1988.
2. R. E. Collin, "Foundations of Microwave Engineering", McGraw Hill, 2001.
3. H.A. Watson, "Microwave Semiconductor Devices and Their Circuit Applications", 1969.
4. C.A. Balanis, "Antenna Theory", Harper & Row. Pub. & Inc., New York, 1997.
5. S.Y.Liao, "Microwave Devices & Circuits", PHI.
6. H.J. Reich, "Microwave Principles", PHI, 1990.

Course code	PH-534
Course title	Physics of Polymer
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The main aim of the course is to enable the students about the physics of polymer and its physical properties. Students will learn the processing techniques and applications of polymers.

Course Outcome:-After completing the course students will be

CO 1	understand the physics and chemistry of polymers.
CO 2	able to know different types of polymer and its characteristics.
CO 3	able to study the mechanical and elastic behaviour of polymeric material.
CO 4	provides a knowledge of polymer processing techniques and applications

Syllabus

Induction to Polymer Science: Fundamental definition, Configurational state, Homopolymer & Copolymer, Degree of polymerization, Thermal transitions and Physical structures - linear, Branched, Crosslinked polymer & Network, Number Average and Weight Average, Molecular Weight, Significance of Molecular Weight.

Rheology and the mechanical properties of polymers: Viscous Flow, Kinetic Theory of Rubber Elasticity, Visco Elasticity, the glass stage and the glass transition, the Mechanical Properties of Crystalline Polymers.

Polymer processing: Plastic, Rubber and Fiber of Commercial Importance, Polymer Auxiliaries, Plasticizers, Stabilizers, Fillers, Lubricants etc., Manufacture Processing and Properties of Major Thermosetting Resins. Thermoplastics, Elastomers and Fiber Forming Polymers, Reinforcement, Fabrication, Formulation, Vulcanization Theory and Technology. Applications of Polymers

Book Recommended:

1. Gowariker V.R., Viswanathan N. V. and Sreedhar J, "Polymer Science", Wiley-eastern, 1991.
2. Ghosh P "Polymer Science and Technology of Plastics and Rubber", Tata McGraw Hill, 1990.
3. Billmeyer F.M "Text Book of Polymer Science", John Wiley and Sons, New York, 1984.

Course code	PH-535
Course title	Digital Electronics
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Electronics PH-513
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on "Digital Electronics" is to introduce the digital concepts to the students. They will be able to learn about digital logic and various components of a digital circuit.

Course Outcomes: Following are the course outcomes:

CO 1	Students will understand digital logic, minimization of the digital logic and its realization in digital circuits.
CO 2	Students will learn about timing of circuits and associated digital components.
CO 3	Students will about registers, counters and their use in digital electronics.
CO 4	Students will understand the working of various digital memories and their implementation.
CO 5	Students will be able to design circuits to convert analog signal to digital and vices versa.

Syllabus

Boolean Algebra and Combinational Logic: Review of Boolean Laws & Theorems; Logic Families; TTL NAND operation, Gate circuits; Standard forms of Boolean expressions (SOP & POS form) and their implantation; Karnaugh simplification of SOP & POS expressions, Don't care conditions. Multiplexer and Demultiplexer; Comparators, Encoder and Decoder; Parity generators and checkers, Adder-Subtract circuits.

Latches, Flip-Flop and Timers: Clock waveform and its characteristics; RS, JK, JK- master slave, Timer-555, D and T Flip Flops (Unlocked, Locked and Edge triggered).

Registers and Counters: Buffer register, control register, Shift Registers (SISO, SIPO, PISO and PIPO), Control shift register**;** Modulus of Counter; ripple counters, ring counter, Asynchronous 2-bit, Up/Down and decade counter; Design of synchronous counter (Mod-8), TTL counter.

Memories: ROM, PROM and EPROM, RAM, Static and Dynamic Random Access Memories (SRAM and DRAM), content addressable memory, other advanced memories.

D/A and A/D Converters: Parallel comparator A/D converter, successive approximation A/D converter, Counting A/D converter, Dual slope A/D converter, A/D converter using voltage to frequency and voltage to time conversion – accuracy and resolution. D/A converter resistive network, accuracy and resolution.

Books Recommended:

1. "Modern Digital Electronics", R. P. Jain, Tata McGraw-Hill Publishing Company; 4th Edition (2009).
2. "Digital Principles and Applications", D. P. Leach, Albert Paul Malvino and G. Saha, McGraw-Hill Publishing Company (2010).
3. "Digital Fundamentals", T. L. Floyd, Pearson Prentice-Hall (2011).
4. "Digital Electronics: Circuits and Systems", V. K. Puri, Tata McGraw-Hill Publishing Co. Ltd. (2001).

Course code	PH-536
Course title	Nuclear Instrumentation
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
This course provides the student with the fundamental skills to understand the basic of Ionizing Radiations, source of radiations, radiation detectors and medical instrumentation using radiation sources. Further the course provide an in depth knowledge of various protocols used for the nuclear and radiation. Students equipped with the knowledge and training provided in the course will be able to participate in design, development and operation in the different area radiation measurements and assessment of radiological doses and health risk assessment.

Course Outcome:-After completing the course students will

CO 1	be understanding basics of ionizing radiations and their applications in different areas.
CO 2	understand about different radiation detectors and medical instrumentation in different modes.
CO 3	understand about Operational safety instrument, emergency schemes, effluent disposal, application to medical diagnosis and treatment.
CO 4	be able to compare protocols of measurements, legal issues, advantages, disadvantages and limitations of various detectors

Syllabus

General: Introduction to Properties of Nuclear Systems & Radiation, Interaction of radiation with matter, radioactive sources- choice of isotopes.

Radiation detectors- Radioactivity and matter: Nuclear properties; Radiation detection and measurement. Ionization chamber, Geiger Muller counters, Scintillation counters, Semiconductor devices, Neutron detectors based on recoil measuring circuits including modulators; converters & stabilizers, Synchronous detectors. Nuclear techniques and analytical instruments, X.R.F techniques, Industrial instruments, density estimation of the fluids, Medical instrumentation, thyroid estimation, CT, MRI. Gamma Ray Spectroscopy Technique.

Safety: Hazards of ionization radiation, physiological effect of radiation, dose and risk radiological protection (alpha, beta and gamma, X, neutron)-shielding material and effectiveness. Operational safety instrument, emergency schemes, effluent disposal, application to medical diagnosis and treatment. Effects of Ionising Radiations, Induction of cancers, Risk Assessments, Risk factors for cancers, Hereditary disease, Communal risk, Other late effects, Irradiation in pregnancy, System of Radiological Protection, Central principles, Scope of application, Justification of practices, Optimisation of protection, Limitations of doses, Constraints, Comparing risks, Legal controls.

Books Recommended:

1. Vashtell,C.C ,S.G Hewit Nucleonic instrumentation, Newnes,(1965).
2. Michael Sayer and Abhai Mansingh, Measurement, Instruments and Experimental Design in Physics and Engineering, PHI, (2000).
3. Glen F. Knoll, Radiation Detection and Measurement, 4th Edition, Wiley Science, (2010).
4. Modern Physics by G. Aruldhas and P. Rajgopal, Publisher: PHI. ISBN-81-203-2597-4.

Course code	PH-537
Course title	Quantum Field Theory
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Quantum Mechanics-I PH515 and Quantum Mechanics PH-519
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Quantum Field Theory is to enable the students to understand the basic of quantum field theory which will be useful in the field of research**.**

Course Outcome:-After completing the course students will be

CO 1	able to understand the importance of Lagrangian formalism and need of second quantization
CO 2	learning the quantization of real and complex scalar fields and corresponding propagators
CO 3	learning the quantization of Dirac field and about origin of Dirac hole theory
CO 4	able to understand the quantization of electromagnetic field.
CO 5	able to draw Feynman diagram for basic scattering processes and will be able to calculate the scattering amplitude.

Syllabus

Canonical Quantization: Resume of Lagrangian and Hamiltonian formalism of a classical field, Second quantization: Concepts and illustrations with Schrodinger field.

Klein Gordan Field: Quantization of a real scalar field and its application to one meson exchange potential, Quantization of a complex scalar field.

Dirac Field: The Dirac Equation, Relativistic Covariance. Anti-Commutators, Quantization of the Dirac Field, Electrons and Positrons.

Gauge Field: Gauge Invariance and Gauge Fixing. Quantization of the Electromagnetic Field, Propagator, Vacuum Fluctuations.

Interacting Theory and Elementary Processes: Feynman diagrams and their applications, Lowest Order Cross-Section for Electron-Electron, Electron-Positron and Electron-Photon Scattering, Wick's Theorem, Scattering matrix and Higher order corrections.

Books Recommended:

1. Quantum Field Theory, C. Itzykson and J. B. Zuber, McGraw-Hill Book Co, 1985.
2. Quantum Field Theory, L. H. Ryder, Cambridge University Press, 2008.
3. Field Theory, A Modern Primer, P. Ramond, Benjamin, 1980.
4. The Quantum Theory of Fields, Vol I, S. Weinberg, Cambridge University Press, 1996.
5. Introduction to The Theory of Quantum Fields, N. N. Bogoliubov and D. V. Shirkov, Interscience, 1960.
6. An Introduction to Quantum Field Theory, M. E. Peskin and D. V. Schroeder, Westview Press, 1995.

Course code	PH-538
Course title	Nanostructured Materials
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Solid State Physics-I PH-516
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Outcome:-After completing the course students will be

CO 1	understand the general physics and chemistry of nanomaterials
CO 2	understand processing techniques for nanomaterials – both chemical and physical approaches
CO 3	understand the important applications and properties of nanomaterials
CO 4	understand the basics of Nanocomposites their types, properties and applications

Syllabus

1. **Introduction to Nanomaterials** : Types of Nanomaterials, Emergence and challenges in nanotechnology, Properties of Nanomaterials, role of size in Nanomaterials, nanoparticles, nanowires, nanoclusters, quantum wells, conductivity and enhanced catalytic activity compared to the same materials in the macroscopic state, Properties of Nanomaterials: Stability of Nanomaterials, Mechanical properties, Optical, Electrical and Magnetic properties, Nano diffusion.

2**. Fabrication of Nanomaterials**: Synthesis routes for nanomaterials: Bottom-up and top-down approaches, Solid, Liquid, Gas phase synthesis, Hybrid Phase synthesis, Synthesis of bulk Nanostructured materials: Approaches and challenges.

3. **Two Dimensional Nanostructures**: Thin Films, Introduction, Fundamentals of Film Growth, thin film deposition: importance of vacuum, evaporation, molecular beam epitaxy (MBE) and sputtering.

4. **Future Applications**: MEMs, Nanomachines, Nanodevices, quantum computers, Optoelectronic devices, quantum electronic devices, Environmental and Biological applications.

5. **Nanocomposites: An Introduction:** Types of Nanocomposite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured Nanocomposites, Super hard Nanocomposite, Mechanical Properties, Modulus and the Load-Carrying Capability of Nano fillers, Failure Stress and Strain Toughness, Glass Transition and Relaxation Behaviour, Abrasion and Wear Resistance, Permeability, Dimensional Stability Contents, Thermal Stability and Flammability, Electrical and Optical Properties, Resistivity, Permittivity, and Breakdown Strength, Refractive Index, Light-Emitting Devices.

Books Recommended:

1. Nanostructures and Nanomaterials; Synthesis, Properties and Applications; Guozhong Cao Imperial College Press
2. Introduction to Nanotechnology; Charles P Poole, Frank J Owen, Wiley India
3. Handbook on Nanotechnology Vol 5; H S Nalwa
4. Nanostructures: - Fabrication and analysis, Springer
5. Nano: The Essentials, Understanding Nanoscience and Nanotechnology, T Pradeep, McGraw Hill
6. “Nanostructures & Nanomaterials: Synthesis, Properties & Applications”, G. Cao, Imperial College Press (2004).

Course code	PH-539
Course title	Experimental Techniques in Physics
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Same as for M.Sc. (Physics) at NIT, Jalandhar
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The aim of the course on Experimental Techniques in Physics is to introduce the students with the physics fundamentals which are essential for understanding different experimets

Course Outcomes: After completing the course students will

CO 1	have understanding about different microscopy techniques
CO 2	develop understanding about reflection of high Energy electron diffraction , neutron diffraction
CO 3	learn about UV-VIS-NIR spectro-photometer & Ellipsometry
CO 4	have understanding about differential scanning calorimeter and differential thermal analyzer

Syllabus

Unit-I

Optical Microscopy; Scanning Electron Microscopy; Scanning Tunneling Microscopy; Atomic Force Microscopy; X-ray diffraction, Mass Spectrometry, Thermal Characterization.

Unit-II

Transmission Electron Microscopy; Low Energy Electron Diffraction; Reflection of High Energy Electron Diffraction; Neutron diffraction; Electron Spectroscopy for chemical analysis; Auger Electron Microscopy; Secondary ion mass spectroscopy; Electron Energy Loss Spectroscopy, Molecular spectroscopies including Microwave, FTIR, Raman and surface enhanced Raman Spectroscopy.

Unit-III

X-ray Fluorescence; Rutherford back scattering; UV-VIS-NIR spectro-photometer & Ellipsometry; Deep Level Transient Spectroscopy; Thermally Simulated Current; C-V and Admittance Spectroscopy; Hall effect and Time of Flight methods for charge carriers, Differential scanning calorimeter; Differential Thermal Analyzer.

Books Recommended:

- Sayer, M., Mansingh, A., Measurement, Instrumentation and Experiment Design in Physics and Engineering, PHI (2000).
- Nanotechnology - Molecularly Designed Materials : G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.
- Nanotechnology Molecular Speculations on Global Abundance : B.C. Crandall (MIT Press), 1996.
- Nanoparticles and Nanostructured Films–Preparation, Characterization and Application : J.H. Fendler (Wiley), 1998.

Course code	PH-540
Course title	Polymer & Liquid Crystals
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Prerequisites: Solid State Physics PH-516
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All

Course Objective
The main aim of the course is to enable the students about the liquid crystals, polymer, polymer- liquid crystal composites and study their physical properties and potential use in displays.

Course Outcome:-After completing the course students will be

CO 1	understand the general physics and chemistry of polymer and liquid crystal materials
CO 2	understand the chemistry and synthesis of polymer and physical properties
CO 3	able to know a new area of soft condensed matter (Liquid crystals) its physical properties and potential applications.
CO 4	provides an electric and magnetic effects in liquid crystals, polymer based LC composites and technological applications of LC in LCDs.

Syllabus

Polymer:

Introduction, monomer, degree of polymerizations, chemistry of polymers, polymer synthesis and polymer structure, polymers classification, polymer morphology, thermal properties, multicomponent polymeric materials, applications.

Liquid Crystals:

Classification of liquid crystals: Thermotropic and lyotropic, Nematic, Smectic, cholestric, Ferroelectric liquid crystals (LCs), Blue phase LCs, molecular structure of LCs, structure- property relationship of thermotropic liquid crystals. Molecular and mean field theory,Birefringence phenomena, polarizing microscopy, texture identifications and defects, Electric & Magnetic effects, Optical properties of liquid crystals. Liquid crystal composites:polymer and nano-materials dispersed liquid crystals composites, polymer liquid crystals, molecular dynamics between LCs and Dopants.Liquid crystal applications: present and future displays, manufacturing of LCDs, twisted nematic, super-twisted nematic, LED, IPS based displays and overview of LC in advance field's.

Books Recommended:

1. Introduction to Liquid crystal Chemistry and Physics: Peter J. Cooling and M. Hird, Taylor and Francis, (1997).
2. The physics of Liquid Crystals, P.G. De. Gennes, Oxford University Press, (1993).
3. Liquid Crystals, 2nd edition, S. Chandrasekhar, Cambridge University Press, (1992).
4. Liquid Crystal fundamental, S. Singh, D. A. Dunmur, World Scientific, (2002)
5. Handbook of Polymer Science and Technology, M. H. Ferry, CBS, Vol. 2 (2012)
6. Polymer Science, Gowarikar, John wiley and Sons, (1986)
7. Principles of Polymer Science, Bahadur and Sastry, Narosa Publishing House,(2002).

Course code	PH-551
Course title	Mathematical Physics-II
Credits	3-0-0
Course type	For M.Sc. (Physics) students

Pre-requisites: Mathematical Physics-I, PH-512
Course Assessment Method: Both continuous and semester end examination
Topics to be covered: All
Prerequisite: Mathematical Physics, PH-512

Course Objective
The aim of the course "Mathematical Physics-II" is familiarize the students with some of the most important mathematical methods not covered in the course "Mathematical Physics", PH-512. Students will learn about the representation theory of groups, their application to the various branches of Physics, probability and statistics.

Course Outcomes: Following are outcomes of the course:

CO 1	A very important branch of mathematics called "Group theory" will be introduced. Students will be familiar about the basics of group theory, various groups and their properties.
CO 2	Students will learn about the representation theory of groups. They will learn how about various concepts and theorems leading up to the character table for finite groups.
CO 3	Students will learn about the continuous groups, Lie groups, their generators and various groups important in the field of Physics.

CO 4	After learning the basic theory behind various groups, students will learn about the applications of the theory in the various branches of Physics, such as Solid State Physics, Quantum Physics, Atomic Physics and Particle Physics.
CO 5	Students will be familiar with the Probability theory, probability distributions, their properties and transformation of random variables.
CO 6	Statistics will be introduced to the students where they will learn about how errors propagate. They will learn about fitting curves to data, various distributions and about confidence intervals.

Syllabus

Group Theory: Definition of a group, Multiplication table, Conjugate elements and classes of groups, directs product, Isomorphism, homomorphism, permutation group.

Representation theory of finite groups: Representation of groups, equivalent representations, reducibility of a representation, Schur's lemmas and the orthogonality theorem, characters of a representation, Orthogonality property of characters, character table, product representations.

Continuous groups: Continuous groups, Lie groups and their generators, $SO(2)$, $SO(3)$, $SU(2)$ and $SU(3)$ groups.

Applications of groups theory: Vanishing integrals, symmetry and degeneracy. Symmetry in crystals and molecules, Crystallographic point groups, translation and space groups, molecular point groups, irreducible representations of point groups, the double group and crystal field splitting.

Probability: Review of probability theory, counting permutations and combinations. Random variables and distributions (discrete & continuous and their properties), binomial, Poisson and Gauss distributions. Limits of Poisson and Binomial distributions. Transformations of random variables (addition and multiplication/division), Gamma distribution.

Statistics: Error propagation, fitting curves to data, the chi-square distribution, the t-distribution, confidence intervals.

Books Recommended:

1. "Mathematical methods for physicists", Arfken, Weber and Harris, Academic press.
2. "Mathematical methods for physics and engineering", Riley, Hobson and Bence, Cambridge University Press.
3. "Elements of group theory for physicists", A W Joshi, New Age International Publishers.
4. "Group theory with applications in chemical physics", P Jacobs, Cambridge University Press.
5. "Molecular quantum mechanics", Atkins and Friedman, Oxford University Press.