

चौधरी चरण सिंह विश्वविद्यालय, मेरठ।
Chaudhary Charan Singh University, Meerut



Syllabus of:

M.Sc. (Physics)

**(As per guidelines of U.P. Government according to
National Education Policy-2020 w.e.f. the session 2025-2026)**

(For University Campus)

Members from the Board of Studies for UG and PG

S. No.	Name	Designation	College/ University	Signature
1.	Prof. Jaimala	Dean, Science Faculty	C.C.S. University Campus, Meerut	
2.	Prof. Anil K. Malik	Convener-I	C.C.S. University Campus, Meerut	
3.	Prof. Beer Pal Singh	Member	C.C.S. University Campus, Meerut	
4.	Dr. Sunil Kumar Sharma(I)	Convener-II	N.A.S. (PG) College, Meerut	
5.	Dr. Sachin Kumar	Member	A S (PG) College, Mawana	
6.	Dr. P S. Negi	Member	Meerut College, Meerut	
7.	Prof. Mahavir Singh	External Subject Expert	Himachal Pradesh University Shimla, HP	
8.	Prof. Rajesh Kharab	External Subject Expert	Kurukshetra University, Kurukshetra, Haryana	
9.	Prof. Pawan kumar Kulriya	External Subject Expert	JNU, New Delhi	
10.	Prof. Vijay Garg	Principal	Kisan P.G. College, Simbhaoli	
11.	Dr. Mukesh Jewariya	Principal Scientist	CSIR-National Physical Laboratory, New Delhi	

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SUBJECT: Physics

Semester-wise Titles of the Papers in M.Sc. (Physics) Colleges Only

Year	Sem.	Course Code	Paper Title	Core Compulsory/ Elective/ Value added	Theory/Practical	Credits
I	I		Mathematical Methods in Physics	Core Compulsory	Theory	04
			Classical Mechanics	Core Compulsory	Theory	04
			Quantum Mechanics-I	Core Compulsory	Theory	04
			Electronic Devices	Core Compulsory	Theory	04
			Practical Course	Core Compulsory	Practical	04
			Industrial Training/Research Project/Survey	Core Compulsory	Project	04
			Basic Science	Open Elective for other faculty	Theory	04
	II		Quantum Mechanics-II	Core Compulsory	Theory	04
			Statistical Mechanics	Core Compulsory	Theory	04
			Electrodynamics	Core Compulsory	Theory	04
			Atomic and Molecular Physics	Core Compulsory	Theory	04
			Practical Course	Core Compulsory	Practical	04
			Industrial Training/Research Project/Survey	Core Compulsory	Project	04
			Nanoscience and Nanotechnology	Open Elective for other faculty/Value added	Theory	04

Year	Sem.	Tracks	Cour se Code	Paper Title	Core Compulsor y/ Elective/ Value added	Theory/ Practical	Credits
II	III	Track -I		Nuclear And Particle Physics	Core Compulsory	Theory	04
				Condensed Matter Physics	Core Compulsory	Theory	04
				Electronics-I Operational Amplifier and Digital Circuits	Elective	Theory	04
				Electronics-II Electronic Communication Systems	Elective	Theory	04
				Electronics Practical Lab	Elective	Practical	04
			Industrial Training/Research Project/Survey		Core Compulsor y	Project	04
	IV	Track-I		Numerical Methods and Programming	Core Compulsory	Theory	04
				Physics of Nanomaterials	Core Compulsory	Theory	04
				Electronics-III Microwave Electronics, Digital And Satellite Communication	Elective	Practical	04
				Electronics-IV Design and Fabrication of Integrated Circuits	Elective	Practical	04
				Electronics Practical lab	Elective	Practical	04
			Industrial Training/Research Project/Survey		Core Compulsory	Project	04

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Syllabus for M.Sc. Physics Chaudhary Charan Singh University Campus

Program: M.Sc.	Subject: Physics
Year: First	Semester: First
Course Code:	Core: Compulsory
Course Title: MATHEMATICAL METHODS IN PHYSICS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To understand the various important mathematical methods in physics.
- To provide basic skills necessary for the application of mathematical methods in physics.
- To understand the mathematical methods in order to analyse theories, methods and interpretations.
- To develop understanding among the students how to use mathematical methods in their field of study of research and in the field of scientific knowledge to work independently

Course Outcomes:

After completing the course, students will be able to:

- Explain Legendre, Hermite, Laguerre and Bessel polynomials, and their applications in physics and engineering.
- Solve the research problems based on the complex variables, integral of complex functions,
- Earn the solution of various mathematical equations using Laplace transformation.
- Use Fourier series and transformation in some spectroscopic analysis.
- Understand the use of mathematical methods in their various branches of physics and engineering.
- The content given in 'Special functions and polynomials' of this course will impart skills for

Unit	Topics	No. of Hours
I	Special functions and polynomials: Graphical representation of basic mathematical functions. Solution of Legendre, Hermite and Laguerre differential equations. Generating function, Rodrigues's formula, recurrence relations, and orthogonality for Legendre, Hermite and Laguerre functions. Introduction of Associated Legendre polynomials. Solution of Bessel differential equation, Bessel functions of first kind. Generating function, recurrence relations and orthogonality for Bessel function. Expansion and integral of Bessel functions, Applications of special functions.	15
II	Complex Variables: Brief overview of complex numbers. Functions of a complex variable. Derivative and Cauchy Reimann equations. Analytic and harmonic function, Integration in the Complex plane, Line integrals of complex functions. Cauchy's integral theorem, Cauchy's Integral Formula. Laurent expansion, Classification of Singularities, Principal value of an integral. Cauchy's Residue theorem and evaluation of some typical real integrals using this theorem. $\int_0^{2\pi} f(\sin\theta, \cos\theta)d\theta$, $\int_{-\infty}^{\infty} f(x) dx$, $\int_{-\infty}^{\infty} f(x) e^{iax} dx$	15
III	Laplace Transforms: Laplace Transform, Laplace transform of elementary Functions. First and second shifting theorems, Inverse Laplace transforms, Solutions of simple differential equations. Laplace transforms of derivative and integral of a function. Applications of Laplace Transform.	15
IV	Fourier Series and Fourier Transform: Fourier series, Fourier series of even and odd functions. Half range expansion, Arbitrary period. Fourier integral and its complex form. Fourier transforms, Fourier sine and cosine transforms. Application of Fourier series and transformation.	15

Essential/ Recommended Readings:

- Mathematical method for Physics by G. Arfken
- Advanced Engineering Mathematics by E. Kreyszig
- Special Functions by E. D. Rainville
- Special Functions by W.W. Bell
- Complex Variables and Applications – Churchill
- Mathematical Method for Physicists and Engineers by K.F.Reily, M.P.Hobson and S.J.Bence
- Mathematical Physics by H.K. Das

Program: **M.Sc.**

Subject: **Physics**

Year: **First**

Semester: **First**

Course Code:	Core: Compulsory
Course Title: CLASSICAL MECHANICS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To study the mechanics of dynamical systems using Lagrange's equations of motion for conservative and non-conservative systems through Lagrangian formulation.
- To study variational principle and solve basic problems using calculus of variations.
- To understand the problem of two bodies moving under the influence of a mutual central force motion of the Lagrangian formulation.
- To understand the theory of small oscillations applied in many physical applications with the concept of stable and unstable equilibrium.
- To study and understand the Hamiltonian formulation for solving of mechanical problems using Hamilton's equations of motion.

Course Outcomes:

After completing this course, students will be able to:

- Solve the mechanics of dynamical systems using Lagrange's equations of motion for conservative and non-conservative systems through Lagrangian formulation.
- Understand the variational principle and its application to solve mechanical problems using Lagrangian formulation.
- Deal with the problem of two bodies moving under the influence of a mutual central force motion.
- Understand the theory of small oscillations applied in many physical applications.
- Solve mechanical problems using Hamilton's equations of motion by Hamiltonian formulation.

Unit	Topics	No. of Hours
I	Review of Elementary Principles and Lagrange's Equations of Motion: Overview of mechanics of a particle and system of particles, Types of Constraints on dynamical systems with suitable examples, Conservation theorems, D'Alembert's principle, generalized coordinates and generalized force, Derivation of Lagrange's equations, Velocity-Dependent potentials and the Dissipation function, Applications of Lagrangian formulation: single particle in space, Simple pendulum with rigid support, Atwood's machine, Time-dependent constraint-bead sliding on rotating wire.	15
II	Variational Principles and Lagrange's Equations: Hamilton's principle, Some techniques of the calculus of variations: Shortest distance between two points in a plane, Minimum surface of revolution and the brachistochrone problem, Derivation of Lagrange's equation from Hamilton's principle, advantages of variational principle formulation, Canonical or Conjugate momentum, Cyclic coordinates and conservation of conjugate momentum.	15
III	Two Body Central Force Problem and Small Oscillations: Reduction to the equivalent one-body problem, Equations of motion	15

	and first integrals, Equivalent one-dimensional problem and classifications of orbits, Virial theorem, The inverse square law of force, Kepler problem, Concept of small oscillations: stable and unstable equilibrium, Formulation of the problem: Expression of kinetic energy and potential energy for small oscillations	
IV	Hamiltonian equations of motion: Legendre transformations and Hamilton equations of motion, Representation of Hamilton's equations of motion in matrix notation, Cyclic coordinates and conservation theorems, Derivation of Hamilton's equations from a variational principle, Principle of least action, Equations of canonical transformation, generating functions, Poisson brackets and canonical invariants, Relation of Poisson brackets, Hamilton-Jacobi Theory: Hamilton-Jacobi equation for Hamilton's principal function.	15
Essential/ Recommended Readings: • Herbert Goldstein, Charles P. Poole, John Safko: Classical Mechanics • N.C. Rana and P.S. Joag : Classical Mechanics • Somerfield : Mechanics • Perceival and D. Richards: Introduction to Dynamics		

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Unit

Program: M.Sc.	Subject: Physics
Year: First	Semester: First
Course Code:	Core: Compulsory
Course Title: QUANTUM MECHANICS - I	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To study time-independent and time-dependent Schrodinger wave approach.
- To solve a one-dimensional Schrodinger equation for simple problems.
- To develop theory of angular momenta and addition of angular momenta
- To understand the applicability of angular momenta in several branches of physics

Course Outcomes:

- After completing this course, students will be able to
- To understand the physical and mathematical basis of quantum mechanics for non-relativistic systems.
- To learn mathematical tools needed to develop the formal theory of quantum mechanics.
- To understand the measurement process in quantum mechanics.
- Understand the connection between measurement of results and the uncertainty relation.
- Understand the application of wave function theory in quantum mechanics.
- Appreciate the amazing power and surprises of quantum mechanics in problems like free particle and particle in a potential.
- Recognize the applicability of angular momenta in several branches of physics.
- Appreciate the profound strength of approximate methods in problems like Stark effect, Zeeman effect, etc.

- Understand the scattering processes that take place in atomic, subatomic, and molecular systems.

Unit	Topics	No. of Hours
I	Fundamental Concepts: Wave packets, Commutator algebra and uncertainty relation, Motion of wave packets, Wave functions in position and momentum space. Operators, Hermitian operators, Degeneracy, Orthonormality and Completeness. Linear operators, Dirac notation, Matrix representations, Change of basis, Three dimensional potential well and Hydrogen atom, vector and Hilbert Spaces, Bases, Dimension, Subspaces, Dual spaces, Inner product of spaces, Dirac notations, matrix representation of operators, Linear harmonic oscillator in matrix formulation, Rotation generators, Transformations of dynamical variables, Symmetry and conservation laws. Symmetric and anti-symmetric wave-functions and Pauli Exclusion Principle.	15
II	Quantum Dynamics and Approximate Methods: Time independent first and second order perturbation theory for non-degenerate and degenerate levels, Variational method, and its application for Helium atom, WKB Approximation. Application of electric field (Stark effect), Dipole Polarizability of ground state Hydrogen atom, normal and anomalous Zeeman Effect.	15
III	Theory of Angular momentum: Commutation relations involving angular momentum operators, the eigenvalue spectrum, Matrix representation of J , Addition of angular momentum, Clebsch-Gordon coefficients, Spin angular momentum, Spin wave functions, Addition of spin and orbital angular momentum.	15
IV	Scattering Theory: Laboratory and centre-of-mass systems, scattering by potential field, scattering amplitude, differential and total cross sections, phase shift, Lippmann-Schwinger equation, and First Born approximation.	15

Essential/ Recommended Readings:

- R. Shankar, Principles of Quantum Mechanics, Second Edition, Springer.
- E. Merzbacher, Quantum Mechanics, Third Edition, Wiley.
- Quantum Mechanics by S. Gasiorowicz.
- Quantum Mechanics by Zetle
- A text book of Quantum Mechanics by P.M. Mathews and K. Venkatesan
- Introduction to Quantum Mechanics by E. Merzbacher
- Quantum Mechanics by L.I. Schiff
- Quantum Mechanics by I. S. Tyagi

Program: M.Sc.	Subject: Physics
Year: First	Semester: First



Course Code:		Core: Compulsory
Course Title: ELECTRONIC DEVICES		
Credits (in hours per week): 4	4L-0T-0P	
Internal Assessment: 30 Marks	External Assessment: 70 Marks	
Course Objectives: • To study the transport mechanism of elemental and compound Semiconductors. • To study the effect of dopant concentration and temperature on devices performance. • To study the junction characteristics of p n- and metal-semiconductor diodes. • To learn and understand the FET transfer characteristics. • To learn and understand the role of metal oxide layer in MOSFETs. • To study the basic role of an amplifiers in modern devices.		
Course Outcomes: • To understand the conduction mechanism of elemental and compound semiconductors for designing the electronic components and circuits. • Understanding the basic phenomenon of semiconductors, it can be used for the fabrication of modern devices. • Having the knowledge of semiconductors, junction diodes, diode and transistor biasing, and amplifies, students can have the job in semiconductor and microelectronic Industries, communication and telecommunication government and private sectors.		
Unit	Topics	No. of Hours
I	Conduction Mechanism in Semiconductors: Basic carrier transport mechanisms in semiconductors; Direct and indirect bandgap, Electron and hole concentrations in bands for degenerate and non-degenerate states, Elemental and compound, Amorphous and crystalline phase in Semiconductors; Carrier concentrations, Conductivity, mobility in Semiconductors; Fermi Level, electron and hole concentrations at equilibrium; Temperature dependence of carrier concentrations, drift and diffusion of charge carriers; Effect of dopant concentration and temperature on the mobility, The continuity equation.	15
II	P-N junction & Metal-semiconductor diode: Qualitative theory of P-N junction, Space charge at a junction, Capacitance of p-n junctions; Generation and recombination charge carriers, Diffusion capacitance; Breakdown mechanisms: Thermal instability, Tunnelling and avalanche multiplication; Transient and noise behavior, device performance as the rectifier, voltage regulator; Device structure and energy band diagram, Schottky effect, Barrier height; Voltage dependence of semiconductor surface potential, Current transport mechanisms, Device capacitance, Ohmic contact.	15
III	Field Effect Transistors: JFETs: Drain, source and Gate, Transfer characteristics, Current equations, Pinch off voltage and its significance; The FET small signal model, Measurement of g_m and r_d , JFET fixed bias, Self-bias and voltage divider configurations, JFET source follower (common-Drain) configuration; JFET Common Gate	15

	configuration; MOSFET- Characteristics, Threshold voltage, Channel length modulation, D-MOSFET, E-MOSFET Characteristics, Comparison of MOSFET with JFET; Depletion and enhancement type MOSFETs	
IV	Feedback Amplifiers: The transistor as an Amplifier, Analysis of a Transistor amplifier circuit using h parameters, Hybrid π model, Ebers-Moll model, Transistor biasing and thermal stabilization; Classification of Amplifiers, Feedback concept, Ways to introduce negative feedback in Amplifiers, Effect of negative feedback, Method of analysis of a feedback amplifier, Voltage-series feedback, Current-series feedback, Voltage-shunt feedback, Current-shunt feedback, Nyquist criterion for stability of feedback amplifiers.	15

Essential/ Recommended Readings:

- Physics of Semiconductor Devices by S.M. Sze & Kwok K. Ng
- Solid State Electronic Devices by B.G. Streetman
- Electronic Devices and Circuit Theory by R.L. Boylested and L. Nashelsky
- Integrated Electronics by J. Millman and C.C. Halkias
- Introduction to Semiconductor Devices by M. S. Tyagi
- Electronic Devices and Circuits by Balbir Kumar and S.B. Jain

Program: M.Sc.	Subject: Physics
Year: First	Semester: Second
Course Code:	Core: Compulsory
Course Title: QUANTUM MECHANICS - II	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To teach the students various approximation methods in quantum mechanics.
- To teach Klein-Gordon and Dirac approaches to under Relativistic quantum theory
- To teach the importance of quantization of electromagnetic radiation in science
- To make the students understanding about introductory quantum field theory.

Course Outcomes:

- Understand the time-dependent Schrodinger wave approach and its applications in real life
- Understand the importance of second quantization connection between symmetries, degeneracies, and conservation laws.
- Understand the importance of second quantization
- Differentiate between classical and quantum identical particles.
- Get basic information needed for advanced courses like quantum field theory.
- The course contents like quantum transitions process for solid-state and gas lasers, the process of second quantization and part of field theory are directly useful for employment.

Unit	Topics	No. of Hours
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I	Approximation Methods (Time Evolution): First order perturbation, Interaction of an atom with an electromagnetic field, Transition probabilities, Fermi Golden rule, Dipole approximation. Einstein's coefficients based on quantum mechanics, Induced and spontaneous emissions of radiations, Applications of transition quantum theory in gas and solid-state lasers, adiabatic approximation.	15
II	Quantum Theory of Radiation: Classical radiation field, Fourier decomposition and electromagnetic radiation field, dipole approximation, Second Quantization, Creation, annihilation and number operators, Photon states, Basic matrix elements for emission and absorption, explanation of stimulated and Spontaneous emission on the bases of quantum mechanics, Importance of second quantization, Plank's radiation law.	15
III	Relativistic Quantum Theory: Klein-Gordon equation and its plane wave solution, Probability density in KG theory, Difficulties in KG equation, Dirac equation for a free electron, Dirac matrices and spinors, Plane wave solutions, Charge and current densities, Existence of spin and magnetic moment from Dirac equation of electron in an electromagnetic field. Dirac equation for central field with spin orbit interaction, Energy levels of Hydrogen atom from the solution of Dirac equation, covariant form of Dirac equation.	20
IV	Introduction of Quantum Field theory: Motivation: need for field quantization, Canonical quantization of scalar fields, Commutation relations and particle interpretation, Fermionic field quantization (outline only) Elements of Feynman Diagrams and QED Processes: Propagators and interaction vertices, Simple processes: Compton scattering, $e^+ e^-$ annihilation, Symmetries in field theory.	10

Essential/ Recommended Readings:

- Quantum Mechanics and Atomic Physics by S.P. Khare.
- Quantum Mechanics by L.I. Schiff
- Modern Quantum Mechanics by J.J. Sakurai
- A Text Book of Quantum Mechanics by P.M. Mathews and K.Venkatesan
- Quantum Mechanics by A. P. Messiah
- Relativistic Quantum Mechanics: J.D. Bjorken and S.D. Drell.
- Relativistic Quantum Fields: J.D. Bjorken and S.D. Drell.
- A First Book on Quantum Field Theory: Amitabha Lahiri and P.B. Pal
- Modern Quantum Mechanics: J.J.Sakurai.
- Principles of Quantum Mechanic: R. Shankar.

Program: M.Sc.	Subject: Physics
Year: First	Semester: Second
Course Code:	Core: Compulsory

Course Title: STATISTICAL MECHANICS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To understand the analysis of the statistical macroscopic quantities of various systems in terms of constituents.
- To learn the ensemble theory and their macroscopic parameters. The application of Bose Einstein statistics and Fermi-Dirac statistics to analysis the properties of ideal Bose gas and Fermi-Dirac gas.
- To understand the various models of cluster expansion of thermodynamic variables. To learn the Random Walk Problem.

Course Outcomes:

- After completion of the course, the students will have the basic knowledge of statistical mechanics.
- Students will be able to calculate the statistical quantities of various systems.
- Students will be able to explain the ensemble theory required for macroscopic properties of the matter in bulk in terms of its constituents.
- Students will understand the analysis of properties of ideal Bose gas, Bose- Einstein condensation, Degeneracy Pressure and electron gas.
- Students will be able to understand the various theories and models of cluster expansion of thermodynamic variables.
- Students will have the knowledge to explain the theoretical aspect of order-disorder phase transition in various systems.
- Students will have the knowledge to explain the theoretical aspect of Ising Model.

Unit	Topics	No. of Hours
I	Ensembles and Statistics of Ideal Gas System: Scope and objective of statistical mechanics. Analysis of phase space, phase points, phase trajectory, Ensemble. Density of phase points, Liouville's theorem in statistical mechanics (with proof), Microstates and Macrostates, Number of accessible microstates. Detailed analysis of micro canonical, canonical and grand canonical ensembles and their properties. Partition function formulation. Fluctuation in energy and particle. Equilibrium properties of ideal systems: classical ideal gas, Harmonic oscillators, Para magnetism, concept of negative temperature.	15

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II	Quantum Statistical Mechanics: The entropy of mixing of ideal gas and Gibbs paradox, Sackur-Tetrode equation, Quantum Statistical Mechanics: Transition from classical statistical mechanics to quantum statistical mechanics, Postulates of quantum statistical mechanics, Density matrix, Indistinguishability and quantum statistics, identical particles and symmetry requirements. Basic postulate and particle distribution function of Maxwell, Fermi-Dirac and Bose Einstein statistics.	15
III	Fluctuation and Degeneracy: Energy, number of particles and pressure of B.E. gas, Bose Einstein Condensation, Energy, number of particles, temperature and pressure of F.D. gas, the electron gas in metals, Degenerate electron gas-equation of state, degeneracy temperature, specific heat. Degenerate Bose Gas, Specific heat and pressure, Black body radiation: Planck's formula and Boltzmann's law, Energy fluctuation in canonical and grand canonical ensembles.	15
IV	Statistical models for order-disorder phase transition: Statistical models for order-disorder phase transition: Cluster expansion for a classical gas, virial equation of state, Ising model, mean-field theories of Ising model, Random walk Problem.	15

Essential/ Recommended Readings:

- Statistical and Thermal Physics by F. Reif
- Statistical Mechanics by K. Huang
- Statistical Mechanics by R. K. Pathria
- Statistical Mechanics by R. Kubo
- Statistical Physics by Landau and Lifshitz
- Statistical Mechanics and properties of matter, theory and application by E.S.R. Gopal

Program: M.Sc.	Subject: Physics
Year: First	Semester: Second
Course Code:	Core: Compulsory
Course Title: ELECTRODYNAMICS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To develop a deep understanding of classical electromagnetic theory from Maxwell's equations.
- To analyze the behavior of electric and magnetic fields in various media and configurations.
- To study wave propagation in vacuum and materials, including dispersion and polarization.

- To explore the radiation from moving charges and the concept of energy-momentum in fields.
- To introduce relativistic electrodynamics and covariant formulation.

Course Outcomes:

After completing this course, students will be able to

- Apply Maxwell's equations to analyze electric and magnetic fields.
- Understand and describe electromagnetic wave propagation in different media.
- Use scalar and vector potentials with appropriate gauge choices.
- Evaluate radiation from moving and accelerated charges.
- Formulate electrodynamics using relativistic and covariant notation.

Unit	Topics	No.of Hours
I	Maxwell's Equations and Boundary Conditions: Review of vector calculus and Dirac delta function; Gauss's law, Faraday's law, Boundary conditions on $\vec{E}$, $\vec{D}$, $\vec{B}$, $\vec{H}$; Ampere's law with Maxwell's correction; Maxwell's displacement current; Maxwell's equations in differential and integral forms, Maxwell's equations in terms of vector and scalar potentials; Poynting theorem; Plane Electromagnetic Wave.	15
II	Propagation of electromagnetic Waves: Plane electromagnetic waves in free space, dielectrics and conducting media; Reflection, Refraction at an interface between dielectrics, transmission, absorption; Fresnel's relations of polarization by reflection and total internal reflection, Brewster's angle; Electromagnetic wave propagation in waveguide.	15
III	Radiation and Electromagnetic Fields: Definition of radiation; Electric dipole radiation; Magnetic dipole radiation; radiation from an arbitrary source; Power radiated by a point charge, Larmor's formula; radiation reaction; the mechanism responsible for the radiation reaction.	15
IV	Relativistic Electrodynamics: Relativistic Larmor's formula; The structure of spacetime: four-vectors and Minkowski space; Magnetism as a relativistic phenomenon; Electric- and magnetic-field of a point charge in uniform motion; How the fields transform; Covariant form of Maxwell's equations; Electrodynamics in tensor notation; Relativistic potentials.	15

Essential/ Recommended Readings:

- Classical Electrodynamics by J.D. Jackson
- Foundations of Electromagnetic theory by J.R. Reitz, F.J. Milford and R.W. Christy
- Introduction to Electromagnetics by David J. Griffiths
- Elements of Electromagnetics by M. N. O. Sadiku

Program: M.Sc.	Subject: Physics
Year: First	Semester: Second
Course Code:	Core: Compulsory
Course Title: ATOMIC AND MOLECULAR PHYSICS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To develop an understanding of the atomic emission/ absorption spectra of one electron and many electrons' atoms.
- To understand the concept of molecular spectroscopy of diatomic molecules which includes Rotational, Vibrational and Electronic energy levels.
- To gain insight of important characterization techniques such as IR/FTIR, Raman, PES, NMR, ESR etc.

Course Outcomes:

On successful completion of this course, the student will:

- Develop the ability to conceptually understand the atomic spectra of Hydrogen atom and similar a valance electron atoms.
- Be able to understand and interpret the atomic spectra for many electron atoms.
- explain the change in behavior of atoms in external applied electric and magnetic field and corresponding changes in observed spectra.
- Gain sufficient understanding of rotational, vibrational, electronic and Raman spectra of molecules.
- Develop skill in important material characterization techniques like IR/FTIR, Raman, etc.
- Acquire ability to apply Nuclear Magnetic Resonance (NMR) for structure elucidation of synthesized materials.

Unit	Topics	No. of Hours
I	Basic Atomic Physics: 2Introduction to Atomic spectra, Quantum states of an electron in Hydrogen atom. Relativistic corrections for energy levels of hydrogen atom. Concept of spin and fine structure of hydrogen atom. Singlet and triplet States of Helium. Broad features of spectra of alkali elements. Fine structure in Alkali Spectra.	15
II	Many electron atoms: Central field approximation, Atomic wave function, Hartree and Hartree-Fock approximations, Results of Hartree's theory, Spectroscopic Terms: LS coupling, Lande Interval rule, determination of spectral terms for atoms; with two or more Non-equivalent optical electrons, and two or more equivalent optical electrons. Breit's scheme. JJ coupling for many electron atoms. Atom in external field, Zeeman, Paschen-Bach & Stark effects.	15
III	Molecular Physics: Born-Oppenheimer approximation, C classification of Molecules, Types of Molecular Spectra and Molecular Energy States: Pure Rotational Spectra, Vibrational-Rotational Spectra, Raman Scattering, Classical and Quantum theory of Raman effect. Selection rules, Isotope effect, Formation of electronic spectra, fine	15

	structure of electronic bands. Intensity distribution in electronic bands: Franck-Condon principle. Explanation of intensity distribution in absorption and emission bands from Franck-Condon principle.	
IV	Characterization Techniques: Infrared/FTIR Spectroscopy, General description and working of dispersive and FTIR instrument. Interpretation of FTIR spectra. Raman spectroscopy. Nuclear Magnetic Resonance, Chemical Shift, NMR Spectrometer. NMR spectrum analysis.	15

Essential/ Recommended Readings:

- Introduction to atomic spectra by H.E. White
- Spectra of diatomic molecules by Herzberg
- Atoms and molecules by M. Weissbluth
- Quantum theory of Atomic Structure Vol I by Slater
- Quantum theory of molecules and Solids by Slater
- Fundamentals of molecular spectroscopy by C.B.Banwell
- Introduction to molecular spectroscopy by G.M.Barrow
- Molecular spectroscopy by J.M.Brown
- Infrared and Raman spectroscopy: Principles and spectral Interpretation by Peter J. Larkin
- Lasers: Fundamentals and Applications by AjoyGhatak and K. Thyagarajan

Program: M.Sc.	Subject: Physics
Year: Second	Semester: Third
Course Code:	Core: Compulsory
Course Title: NUCLEAR AND PARTICLE PHYSICS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To impart knowledge about nuclear properties.
- To understand the nuclear decay, inter-nucleon forces and related facts.
- To understand the Nuclear reactions.
- To understand the different nuclear detectors.
- To understand the different nuclear models to know fundamental principles and concepts governing nuclear structures
- To understand the particle physics to construct nuclear reactions.

Course Outcomes:

- After completion of the course, students will learn about the nuclear angular momentum and dipole

- moment of nuclei.
- They will understand the concept of inter nucleon forces and related facts.
- Students will understand the parity violation in beta-decay.
- Students will understand nuclear reactions and detectors.
- Students will obtain the knowledge of the nuclear structure and various important nuclear models.
- They will be able to construct nuclear reactions using the conservation laws for elementary particles.
- The knowledge of various detectors will impart skills for direct employability.

Unit	Topics	No. of Hours
I	Nuclear Structure and Nuclear force: Nuclear structure and properties. Binding energy per nucleon, Proton and neutron separation energy. Analysis of nuclear angular momentum, nuclear magnetic dipole moment and nuclear electric quadrupole moment, Parity quantum number. Overview of Deuteron properties. Theory of Deuteron ground state and excited states, two nucleon scattering at low energy, neutron-proton scattering, partial wave analysis, phase-shift, scattering length.	15
II	Nuclear Models: Liquid drop model(Semi- empirical mass formula), Experimental evidence for shell structure in nuclei, Basic postulates of shell model, Single- particle energy levels in central potential, Spin-orbit potential and prediction of magic numbers, Extreme single-particle model, Prediction of angular momenta, Parities and magnetic moment of nuclear ground states in shell model.	15
III	Nuclear Decay, Reactions and Nuclear detectors: Overview of alpha, Gamow theory alpha decay, beta and gamma decay, Fermi theory of beta decay, Parity violation in beta decay, Neutrino, Wu's experiment in beta decay, Internal conversion. Introduction and types of nuclear reactions, conserved quantities of nuclear reaction, energies of nuclear reaction, Q value, Q value for alpha decay reaction, exoergic & endoergic reactions.	15
IV	Particle Physics: Overview of properties, origin and classification of Elementary particles, type of interactions and conservation laws, Noether's theorem, Properties of mesons, Resonance particles, Baryon, Meson Octet and Decuplet, Strange particles and Strangeness quantum number, Gell-Mann Nishijima scheme. Properties of quarks and their classification. Elementary ideas of SU(2) and SU(3) symmetry groups and hadron classification, Quarks, Gell-Mann- Okubu mass formula.	15

Essential/ Recommended Readings:

- Introduction to nuclear Physics by H. Enge
- Theoretical Nuclear Physics by J.M. Blatt and V.F. Weisskopf
- Particle Physics: An introduction by M. Leon
- Nuclear & Particle Physics: An Introduction by B. Martin
- Introduction to Particle Physics by R. Oles.
- Introducing Nuclear Physics by K. S. Krane
- Nuclear Physics: Theory and Experiments by R.R. Roy and B. P. Nigam
- Fundamentals of Nuclear Physics by B.B. Srivastava

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- Nuclear Physics by D.C. Tayal
- Nuclear Physics in A Nutshell by C. A. Bertulani

Program: M.Sc.	Subject: Physics
Year: Second	Semester: Third
Course Code:	Core: Compulsory
Course Title: CONDENSED MATTER PHYSICS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To study some of the basic properties of the condensed phase of matter especially solids.
- Condensed matter Physics is the study of the structure and behavior of the matter that makes up most of the usual stuff that surrounds us every day.
- Condensed Matter Physics is the fundamental science of solids and liquids.
- It has the greatest impact on our daily lives by providing foundations for technology developments.

Course Outcomes:

After completing this course, students will

- Be able to correlate real and virtual lattice which is the key of structure property relationship of any solid.
- Develop skill in X-ray diffraction techniques and its applications.
- Gain knowledge of various crystal imperfections and their impact of properties of the material.
- Also be able to explain electronic and magnetic properties. The knowledge may help them to design new materials with desired electronic and magnetic properties.
- Learn about the basic concept of super conductivity and its application in various fields.

Unit	Topics	No. of Hours
I	Bravais lattice, primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitz cell; Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; point group and space group (information only); Common crystal structures: NaCl and CsCl structure, close-packed structure, Zinc blende and Wurtzite structure, tetrahedral and octahedral interstitial sites, Spinel structure. X-ray diffraction, The Laue, powder and rotating crystal methods, Reciprocal lattice and Brillouin zone; Ewald construction; Explanation of experimental methods on the basis of Ewald construction. Anomalous scattering; Atomic and geometric structure factors; systematic absences. Point defects (Schottky & Frankel Defects) Imperfections, Line defects (Edge & Screw dislocations), Burger vector & Burger Circuit Planer (stacking) faults.	15

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II	Different types of bonding in solids, covalent, metallic, Vander Waal, hydrogen bonding & ionic bonding, Madelung constant of ionic crystals, cohesive energy. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power.	15
III	Electronics Properties of Solids: Electrons in a periodic lattice: Bloch theorem, The Kronig-Penny Model, Effective mass of an electron, Tight-binding approximation, Cellular and pseudopotential methods. Superconductivity: Review of basic properties, Meissner effect, Type-I and Type-II superconductors, thermodynamics of superconductors, London's phenomenological theory, Flux quantization. Elements of BCS theory. Josephson junction and applications.	15
IV	Magnetic Properties of Solids: Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, Ferromagnetic domains, The Bloch-wall, Spin waves and Magnons, Curie- Weiss law for susceptibility, Ferri and antiferro-magnetic order.	15

Essential/ Recommended Readings:

- Verma and Srivastava: Crystallography for Solid State Physics
- Azaroff: Introduction to Solids
- Solid State Physics by S O Pillai
- Omar: Elementary Solid State Physics
- Aschroff&Mermin: SolidState Physics
- Kittel: SolidState Physics
- Chaikin and Lubensky: Principles of Condensed Matter Physics

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Program: M.Sc.	Subject: Physics
Year: Second	Semester: Third
Course Code:	Core: Elective-I (Electronics)
Track -I	
Course Title: OPERATIONAL AMPLIFIER AND DIGITAL CIRCUITS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To learn about the basic and advanced knowledge of amplifier, operational amplifiers.
- To study voltage and current controlled Source, rectifiers, and gains.
- To study the CMOS technology and logic families.
- To study the digital numbers system, logic gates for mathematical operations and memories.
- To design the arithmetic logic circuits and storage data systems: flip-flop, registers. Counters and converters.

Course Outcomes:

At the completion of the course students will be able to:

- To learn for designing of amplifiers, operational amplifiers for various applications.
- To learn for CMOS technology, ICs designing for digital circuit operations.
- Having the knowledge of number systems and logic gates, students can develop the mathematical operations.
- To learn the actual role of Transistors for making ICs and data storage systems.
- After studied and practical learning of logic families, gates, and circuits, the students can get the job in microelectronic component industries, telecommunication industries for designing circuits and their functions.

Unit	Topics	No. of Hours
I	Operational Amplifier and their Application: Characteristics of an ideal operational amplifier, Op-Amp Specifications, DC Off-set parameter, Frequency parameters, Applications of operational amplifiers: Inverting and Non-inverting amplifiers, Unity follower, Voltage summing and subtraction, Integrator, Differentiator, multiple stage gain, Current controlled voltage source, Voltage controlled current source, Rectifiers and Limiters, Comparators and Schmitt Triggers, Active filters.	15
II	Logic Families: Logic gate symbols and truth tables, Classes of digital integrated circuits (Diode logic, DTL, TTL, ECL, MOSFET, CMOS), Transistor- Transistor Logic (TTL), Single Input TTL Inverter (transfer characteristic), Multi- collector transistors, Propagation delays, Diode Logic, DTL NAND Gate (transfer characteristic, noise immunity, fan out), Emitter Coupled Logic (transfer characteristic of OR/NOR gate, practical implementation, MOSFET Logic, MOSFET Inverter, MOSFET NOR and NAND gates, Complementary MOS (CMOS)- CMOS inverter, CMOS NOR and NAND, Power dissipation in CMOS, Advantages/Disadvantages of CMOS.	15
III	Digital Electronics and Logic Gate: Number systems: Binary, Octal, Decimal and Hexadecimal, Base conversion systems, Basic logic gates: OR, AND and NOT, Bubbled gate, Boolean Algebra, De-Morgan's	15

	theorems, Boolean equations of Logic circuits, Combinational logic circuits, NOR and NAND Gates, Sum of Product (SOP) and Product of Sum (POS) methods, Karnaugh map (K-map), pairs, quads and octets, K-map simplifications, Don't care conditions, Product of Sum simplifications, Min-terms and Max-terms, Converting a truth table to an Equations, Exclusive-OR gate, BCD to decimal decoders, Excess-3 code, Gray code.	
IV	Application of Digital Logic Gates: Arithmetic circuits: binary addition and subtraction, 1's and 2's complement arithmetic and representation; Arithmetic building blocks, Half adder and Full adder circuits; Multiplexers and Demultiplexer, RS Flip-Flops: NOR and NAND gate latch, Clocked RF Flip-Flops, Edge-triggered D Flip-Flop, T-Flip Flop, JK Flip-Flop, Flip-Flop timing, JK Master-Slave Flip-Flops; Registers, Types of registers, Serial-in-serial out, Serial-in-parallel out, Parallel-in-serial out, Parallel-in parallel out; Counters: Asynchronous and synchronous counters, Mod-3 and Mod-5 counters, Shift counters; Digital-to-Analog and Analog-to-Digital Converters; Microprocessor- 8085 microprocessor architecture, interfacing devices, BUS timing, Basic terms and ideas of memory.	15

Essential/ Recommended Readings:

- Electronic Device and Circuit: R. Boylested and L. Nashdsky
- Analysis and Design of Digital Integrated Circuit: Hodges, Jackson and Saleh
- Digital Principles and Implementation: A.P. Malvino and D.P. Leach
- Op- Amp and Linear Integrated Circuit: Ramakant A. Gayakwad
- Linear Integrated Circuit: Choudhary and Jain
- Digital Principals and Applications: D.P. Leach & A.P. Malvino

Program: M.Sc.	Subject: Physics
Year: Second	Semester: Third
Course Code:	Core: Elective –II (Electronics)
Track -I	
Course Title: ELECTRONIC COMMUNICATION SYSTEMS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

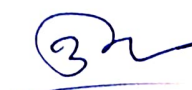
- To enable students to understand the basic concepts of circuits found in radio-communication.
- To interpret and analyze the characteristics of the main components of communication electronics.
- To impart in depth knowledge of different types of analog communication systems and different modulation techniques used in these systems.
- To be able to design the simplest devices and transmitting and receiving systems of radiofrequency series.
- To introduce the various types of transmission lines and to discuss the losses associated.
- To give thorough understanding about impedance transformation and matching.

Course Outcomes:

On completion, the student will be able to:

- Analyze analog communication signals in time domain and frequency domain.
- Distinguish between different analog modulation techniques.
- Analog signal generation techniques.
- Discuss the fundamental concepts of wave propagation in Transmission Lines.
- Analyze the line parameters and various losses in transmission lines.
- Apply smith chart for line parameter and impedance calculations.

Unit	Topics	No. of Hours
I	Amplitude Modulation Systems: Principles of Amplitude Modulation; AM envelope and Equation of AM wave, Modulation index and Percent Modulation, Frequency Spectrum and Bandwidth, AM Power Distribution, AM by Multiple Sine waves, Transmission efficiency, Double Side-Band Suppressed Carrier (DSB-SC), AM Modulator Circuits; Low-level AM Modulator, Medium Power AM Modulator	15
II	Single- Sideband Techniques: Evolution and Description of Single Sideband Modulation (SSB); Suppression of Carrier, Balanced Modulator, Suppression of Unwanted Sideband, The filter. System, The phase-shift method, System evaluation and comparison, Extensions of SSB, Vestigial-sideband Modulation	15
III	Frequency Modulation Systems: Theory of Frequency and Phase Modulation, Relationship between phase and frequency modulation, Mathematical Representation of FM, Phase and frequency deviation, Spectrum of an FM signal, Sinusoidal modulation, Bandwidth of a sinusoidally modulated FM signal, Generation of FM signal, Direct and Indirect Methods	15



IV	Transmission Line Theory & Optical Fiber Communication Systems: Fundamental of Transmission lines, Different types of Transmission lines, Primary line constants, phase velocity and line wavelength, Characteristic impedance, Propagation Coefficient, Phase and group velocities, Standing waves, Lossless line at radio frequencies, Voltage standing wave ratio, Slotted line measurements at radio frequencies, Transmission lines as circuit elements, Drawbacks of Radio communication, Introduction to Optical Communication, Fiber index profiles, Modes of Propagation, Number of Propagated modes in Step-index Fibers, Losses in Fibers.	15
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Essential/ Recommended Readings:

- Modern Electronic Communication by Gary M. Miller, 6th edition
- Electronic Communication Systems by George Kennedy and Bernard Davis, 4th edition
- Principles of Communication Systems by H. Taub and Donald L. Schilling
- Electronic communications by Dennis Roddy and John Coolen
- Electronic Communication Systems-Fundamentals through Advanced by Wayne Tomasi, 4th edition

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Program: M.Sc.	Subject: Physics
Year: Second	Semester: Fourth
Course Code:	Core: Compulsory
Course Title: NUMERICAL METHODS AND PROGRAMMING	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- Be familiar with the MATLAB GUI and basic tool boxes
- Be familiar with arithmetic, logic and relational operations on matrix
- Aware about to find the roots of nonlinear equations by numerical methods
- Learn various methods to solve the matrices
- Learn about interpolation, least square fitting, Numerical differentiation, Integrations, ordinary and partial differential equations.

Course Outcomes:

On completion, the student will be able to:

- Perform data handling in MATLAB environment.
- Write arithmetic programs in MATLAB environment
- Solve the linear and non-linear algebraic equations, Eigen value problems, curve fitting and numerical solution of ordinary differential equations.
- Solve numerical integration & differentiation, curve fitting, Numerical solution of ordinary equations.

Unit	Topics	No. of Hours
I	MATLAB: MATLAB environment, M-Files, Basic syntax and scalar arithmetic operations, variables, Working with formula, MATLAB control flow: if and loops, Functions, structured data types, file input output, defining functions, Graphics, 2D & 3D plotting in MATLAB, Linear algebra with MATLAB, solving a system of linear equations.	15
II	Roots of nonlinear equations: Linear and nonlinear algebraic and transcendental equations, Roots of functions, Bracketing and open end methods: Bisection method, Newton-Raphson method. Matrices and solution of linear equations: Eigen values and eigenvectors of matrices, Power and Jacobi method, consistency of a system of linear equation, Gaussian elimination, LU decomposition method, matrix inversion, Jacobi iterative method, Gauss-Seidel method.	15
III	Interpolation and least square curve fitting: Finite differences, Newton's formula for interpolation, Gauss, Stirling, Divided differences, Newton's general interpolation formula, Lagrange's interpolation formula. Method of Least square curve fitting, straight line and quadratic equation curve fitting, curve fitting of nonlinear equation such as $y = ax^b$, $y = ae^{bx}$, $xy^a = b$ and $y = ab^x$, curve fitting by sum of exponentials.	15
IV	Numerical differentiation, integration and solution of ordinary differential equations: Differentiation of continuous functions, numerical differentiation using Newton's forward and backwards difference formula, Sterling's formula, Numerical integration: Trapezoidal rule, Simpson 1/3 and 3/8 rules, Boole's and waddles rules,	15



	Solution of ordinary differential Equation: Euler, Picard and Runge-Kutta methods, Finite Difference method, and solution of wave & heat equations using Finite element method .	
Essential/ Recommended Readings: • MATLAB programming for engineers, 4th edition by Stephen J. Chapman. • Introductory Methods of Numerical analysis by S.S. Shastri • Numerical Analysis by Rajaraman • Computational method in physics and engineering by Wong • Numerical Methods by E. Balagurusamy • MATLAB for Engineers, 3rd edition by Holly Moore •		

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Program: M.Sc.	Subject: Physics
Year: Second	Semester: Fourth
Course Code:	Core: Compulsory
Course Title: PHYSICS OF NANOMATERIALS	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To understand the Physics of materials (especially engineering materials/IT materials: Semiconductors, insulators & metals) at nanometer scale.
- To understand the phenomena of QSE and Electron Confinement: Quantum well, Quantum wire & Quantum dot.
- To learn the different experimental techniques for determination of particle size: by XRD, Electron microscopy, absorption spectroscopy.
- To learn about the different methods of preparation of nanomaterials.

Course Outcomes:

On completion, the student will be able to:

- Understand the size, shape, and orientation dependent properties of different materials at the nanoscale (1 - 100 nm)
- Acquire the ability to synthesize, and characterize of different materials for different solid state device applications.
- Understand the size dependent properties of materials.
- Determine the particle size of nanomaterials using different tools and techniques.
- Synthesize the desired NSM's for different applications using Top down and Bottom up approaches.

Unit	Topics	No. of Hours
I	Introduction to Nanoscience & Nanotechnology: Nanoscience & nanotechnology, Size dependence of properties, Moore's law, Surface energy and Melting point depression of nanoparticles, Measurement techniques of melting point depression, Qualitative idea of Free electron theory and band theory of solids, E-k diagrams, Energy gaps, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Exciton, Frenkel and Wannier-Mott exciton, Multiple exciton generation in semiconductor nanocrystals, Density of states, variation of density of states with energy and dimensions of crystal.	15
II	Quantum Confinement: Nanostructures & quantum physics, Quantum size effect, Nanomaterials structures, Quantum confinement of different nanostructures, Quantum well, Quantum wire and Quantum dot, Quantum mechanical treatment of nanostructures, Methods for fabrication of nanostructures.	15
III	Characterization techniques of Nanomaterials: Different techniques for determination of particle size, Determination of particle size using XRD, Diffraction under non-ideal conditions, Derivation of Scherrer's formula, Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, Correlation between shift in absorption spectra peak and energy band gap of nanomaterials, Determination of energy band gap and particle size using absorption spectra of nanomaterials, shift in photoluminescence peaks, Electron-	15

Course Outcomes:
Students will be able to:
• Analyze
• Explain

	Specimen interaction, Electron microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe microscopy (SPM), Scanning Tunneling Electron Microscopy (STEM) and Atomic Force Microscopy (AFM).	
IV	Synthesis of Nanomaterials: Key issues in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches with examples of suitable techniques, capping agents, Cluster beam evaporation, Ball Milling, Carbon nanotubes (CNT)& graphene- Synthesis, Properties and Applications	15

Essential/ Recommended Readings:

- Nanostructures & Nanomaterials, Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press.
- Introduction to Nanotechnology by Charles P. Poole, Jr. Frank J. Owens, John Wiley & Sons Inc. Publication.
- Quantum Wells, Wires and Dots by Paul Harrison, John Wiley & Sons Ltd.
- Quantum Mechanics for Nanostructures by Vladimir V. Mitin, Dmitry I. Sementsov, Nizami Z. Vagidov (Cambridge University Press).
- Quantum Dot Hetrostructures, by D. Bimberg, M. Grundman, N.N. Ledenstov.
- Introduction to Nanoscience and Nanotechnology by Hornyak G.L., Tibbals H.F., Dutta J., Moore J.J., CRC Press.
- Carbon Nanotechnology by Liming Dai
- Carbon Nanotubes: Properties and Applications by Michael J. O'. Connell.

Program: M.Sc.	Subject: Physics
Year: Second	Semester: Fourth
Course Code:	Core: Elective-III (Electronics)
Track - I	
Course Title: MICROWAVE ELECTRONICS, DIGITAL AND SATELLITE COMMUNICATION	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

The elemental objectives of this course are;

- To build up the concept from basics of microwave communications to modern applications
- To study digital communication systems (e.g., choose modulation scheme, coherent vs. non-coherent), constraints on data rate, bandwidth, power, and bit error rate
- To compute the power and bandwidth requirements of modern communication systems, including those employing Amplitude-Shift Keying (ASK), Phase-Shift Keying (PSK) and Frequency-Shift Keying (FSK modulation formats
- To enable the student to become familiar with satellites and satellite services.
- Study of satellite orbits and launching.
- Study of earth segment and space segment components

Course Outcomes:

Students will have achieved the ability to:

- Analyze microwave networks and measure their parameters.
- Explain the working of various microwave devices
- Identify the modern-day applications of microwaves.
- Understand the performance of a baseband and pass band digital communication system in terms of error rate and spectral efficiency.
- Understand orbital mechanics and how to locate satellite w. r. t. Earth station
- Describe satellite subsystems
- Design link power budget for satellites

Unit	Topics	No. of Hours
I	Microwave Tubes and Circuits: Generation of Microwaves by Vacuum Tubes; Limitations of Conventional Tubes, Microwave Linear Beam Tubes (O type); Klystrons amplifiers, Velocity Modulation, Basic principles of two cavity klystrons, Multicavity clystron amplifier and Reflex klystron oscillator and Travelling wave tube (TWT), Microwave Crossed Field Tube (M type) Magnetron, principles of operation of magnetrons	15
II	Semiconductor Microwave Devices and Circuits: Transferred electron devices, Ridley-Watkins-Hilsum (RWH) Theory, Gun effect diodes, Principles of operations, modes of operation, Avalanche Transit-Time Devices, Read diode, IMPATT diode, and TRAPATT diode.	15
III	Digital Communication: Pulse Modulation; Sampling theorem – Low Pass and Band Pass signals, Pulse Amplitude Modulation, Pulse Code Modulation, uniform and non-uniform Quantization of signals, Quantization error, Digital Modulation Schemes; Principle of Binary Phase Shift Keying (BPSK), Generation and Reception of BPSK, Bandwidth of BPSK Signal, Differential Phase Shift Keying (DPSK); DPSK Transmitter and Receiver, Bandwidth of DPSK Signal, Quadrature Phase Shift Keying (QPSK); QPSK transmitter and Receiver, Bandwidth of QPSK Signal, Binary Frequency Shift Keying (BFSK), BFSK Transmitter and receiver, Amplitude Shift Keying (ASK).	15
IV	Satellite Communication: Introduction to Satellite Systems, Types of Satellites, Frequency Allocations, Orbital Mechanics; Laws governing satellite motion; Kepler's Laws, Describing the orbits of a Satellite, Locating the Satellite in the Orbit, Locating the Satellite with respect to the Earth, Orbital Elements, Antenna Look Angles determinations, Orbital Perturbations, Satellite link power budget equation, system Noise, carrier to noise ratio for uplink and downlink, combined uplink and downlink carrier to noise ratio.	15

Essential/ Recommended Readings:

- Microwaves by K.C. Gupta
- Microwave Devices and Circuits by Samuel Y. Liao
- Electronic Communication Systems by George Kennedy and Bernard Davis
- Principles of Communication Systems by Taub and Schilling
- Communication Systems by Simon Haykin
- Digital Communications, second edition by J.S. Chitode

- Satellite Communication by Timothy Pratt and Jeremy E. Allnutt

Program: M.Sc.	Subject: Physics
Year: Second	Semester: Fourth
Course Code:	Core: Elective-IV (Electronics)
Course Title: DESIGN AND FABRICATION OF INTEGRATED CIRCUIT	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- To understand the microelectronics.
- To know the process of preparation of electronic grade silicon and crystal growth.
- To understand the various process steps of silicon wafer fabrication.
- To learn the design of circuits using pattern transfer technology (lithography) on silicon wafer.
- To understand the process of ICs fabrication, Isolation, Contacts, Interconnections, and Packaging.

Course Outcomes:

- After completion of course, the students will learn about the integrated circuits (ICs) and technology.
- Students will understand the theory and experimental background of all the actual process like; wafer fabrication, doping, and pattern transfer, etc. used in IC fabrication.
- Students will also learn about exact deposition of thin films of metal, oxides and photoresists, wet/dry etching, and finally the isolation, interconnection, testing and packaging.
- The students will be able to design electronic circuits and devices for semiconductor/microelectronics industry purpose.
- All content of this course will impart skills for direct employability.

Unit	Topics	No. of Hours
I	Semiconductor Substrate for Integrated Circuits: An introduction to microelectronics fabrication, Classification of Integrated Circuits (IC), CMOS Process Overview. Metallurgical Grade Silicon (MGS) and electronic grade silicon (EGS). Crystal growing methods, Silicon shaping, lapping, Polishing and wafer preparation, Oxidation of silicon, Thermal dry oxidation and wet oxidation, Deal-Grove modal of oxidation, linear and parabolic rate coefficient, oxidation systems. Doping by Diffusion, Diffusion Process, Fick's Diffusion equation in one-dimension, Analytic solution of Flick's law. Analysis of diffused profiles, Diffusion in SiO ₂ , Diffusion sources and systems., Ion implantation, Implantation system, Channeling, projected range, implantation damage, Junction formation, Annealing, Dopant Diffusion and Related Operations.	15

II	Thin Films: Metals and Nonmetals: Vacuum science and technology. Thin films and growth modes, Physical vapor deposition (PVD) methods: Thermal evaporation and electron beam evaporation systems, DC and RF sputtering system. Chemicals Vapor Deposition (CVD) methods: APCVD, LPCVD, PECVD and ALD technique, CVD Applications. Epitaxial growth, Epitaxy methods for thin film deposition: Vapor-Phase Epitaxy, Liquid Phase Epitaxy and Molecular Beam Epitaxy (MBE).	15
III	Photolithography, Photoresist Processing and Etching: Wafer Cleaning methods, Wafer Preparation method: HMDS Treatment for adhesion improvement of photoresist, photoresist spin coating method, soft and post backing of photo resist, Negative photoresist, Positive photoresist, Contrast and sensitivity of photoresist, Chemical Modulus Transfer Function (CMTF) of Photoresist, Resist Exposure (single, bi-layer and multi level photoresist exposure) and Resist Development, Hard Baking and Resist curing, Photolithographic Process Control. Photolithography: An Overview, lithography, Photolithography source, Resolution and numerical aperture, Photolithographic methods: Contact, proximity and projection, Photo mask and mask Alignment, Limitations of optical lithography, Concept of phase-shift mask, Electron beam lithography, X-ray lithography and Ion Lithography. Dry etching and wet chemical for material removal, Reactive plasma etching, Ion milling.	15
IV	Device Isolation, Contacts, Interconnections, Packaging and Yield: Junction and oxide isolation, LOCOS methods, Trench isolation, Ohmic Contact, Schottky Contact, Alloyed Contact, Multilevel Metallization, Planarization and advanced interconnects. Testing, Die Separation, Die Attachment, Wire Bonding, Packages, Flip-Chip Process, Tape-Automated-Bonding Process, Yield, Uniform and Nonuniform Defect Densities.	15
Essential/ Recommended Readings: • Integrated Electronics- Milliman and Taub • Microelectronics –Milliman and Gros • Thin Film Phenomena- K.L. Chopra • Hand Book of Thin Film- Marshel and Glang • VLSI Technology- S.M. Sze. • Silicon VLSI Technology: Fundamentals, Practice, and Modeling by J.D. Plummer		

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Program: M.Sc.	Subject: Physics
Year: First	Semester: First
Course Code:	Elective CBCS
Course Title: BASIC SCIENCE	
Credits (in hours per week): 4	4L-0T-0P
Internal Assessment: 30 Marks	External Assessment: 70 Marks

Course Objectives:

- Provide basic understanding and importance of Science to students from non-science backgrounds.
- Enhance scientific literacy and critical thinking abilities.
- Provide knowledge about contributions of ancient and modern Indian scientists.
- Gain knowledge about scientific and technological developments in different branch of science
- Encourage informed decision-making based on evidence and scientific reasoning.

Course Outcomes:

- Explain basic principles of Science and their relevance to everyday phenomena.
- Apply scientific reasoning to interpret natural and technological processes.
- Analyze and evaluate physical situations using qualitative and quantitative reasoning.
- Demonstrate awareness of contemporary issues related to energy, environment, and technology.
- Effectively communicate scientific ideas in simple, accurate terms.

Unit	Topics	No. of Hours
I	Introduction to Science: Definition of Science, Importance of Science, Brief history of Science, Evolution of Science, Broad classification of Science, Philosophy of Science, Impact of Science in daily life, Understanding of Physical Quantities & their Units in Standard & Prefixed forms, Basic understanding of the Universe: Planets, Stars & Galaxies.	15
II	Prominent Scientists of Ancient & Modern India and their Achievements: Mathematics and Astronomy: Baudhayan, Aryabhatta, Brahmgupta, Bhaskaracharya, Varahamihira, Nagarjuna. Medical Science of Ancient India (Ayurveda & Yoga): Susruta, Charak, Yoga & Patanjali. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha and Dr. Vikram Sarabhai.	15
III	Scientific Revolution & Mapping of different branches of Science: Scientific revolution and age of enlightenment, Scale of universe, Hierarchy of Sciences, Mapping of different branches of Science, Social Sciences, Physical Sciences, Life Sciences, Formal Sciences, Basic & Applied Science, Natural Sciences, Emerging of different disciplines of Science, Interdisciplinary approach of Science, Data Science, Science in 21 st Century.	15

IV	Science, Technology and Society: Role of science in modern society; Ethical issues in science and technology; Science communication and misinformation; Space exploration and future technologies; Scientific perspectives on energy and resources; Science in policy-making and sustainable development goals (SDGs)	15
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Essential/ Recommended Readings:

- Bill Bryson, A Short History of Nearly Everything, Broadway Books
- HISTORY OF SCIENCE AND TECHNOLOGY IN INDIA By Dr. Binod Bihari Satpathy
- Isaac Asimov, The Intelligent Man's Guide to Science, Basic Books
- Bill Bryson, A Short History of Nearly Everything, Broadway Books
- National Geographic, Science of Everything, National Geographic Society
- Isaac Asimov, The Intelligent Man's Guide to Science, Basic Books

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