COURSE STRUCTURE
M.SC. (PHYSICS)

EFFECTIVE FROM ACADEMIC SESSION – 2023-24

Approved in Academic Council Meeting held on 13 December 2024

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M.Sc. (PHYSICS) COURSE STRUCTURE
AND DETAILED SYLLABUS OF THE COURSES

Semester I (Credits: 16)

S. No.	Course Code	Course Name	L-T-P	Credit
1.	23MS1PH101	Mathematical Physics	3-0-0	3
2.	23MS1PH102	Classical Physics	3-0-0	3
3.	23MS1PH103	Quantum Mechanics	3-0-0	3
4.	23MS1PH104	Electrodynamics	3-0-0	3
5.	23MS1PH105	Experimental Techniques	2-0-0	2
6.	23MS7PH171	Laboratory-I	0-0-4	2

Semester II (Credits: 17)

S. No.	Course Code	Course Name	L-T-P	Credit
1.	23MS1PH201	Computational Physics	3-0-0	3
2.	23MS1PH202	Statistical Physics	3-0-0	3
3.	23MS1PH203	Condensed Matter Physics-I	3-0-0	3
4.	23MS1PH204	Atomic and Molecular Physics	3-0-0	3
5.	23MS1PH205	Electronics	3-0-0	3
6.	23MS7PH271	Laboratory-II	0-0-4	2

Semester III (Credits: 18)

S. No.	Course Code	Course Name	L-T-P	Credit
1.	18MS1PH311	Electronics-II	3-0-0	3
2.	18MS1PH313	Condensed Matter Physics-II	3-0-0	3
3.	24MS1PH311	Nuclear and Particle Physics	3-0-0	3
4.	18MS1PH312	Advanced Quantum Mechanics	3-0-0	3
5.		Elective-I (Bucket I)	3-0-0	3
6.	24MS9PH391	Project Part-I	0-0-6	3

Semester IV (Credits: 21)

S. No.	Course Code	Course Name	L-T-P	Credit
1.		Elective-II (Bucket II)	3-0-0	3
2.		Elective-III (Bucket III)	3-0-0	3
3.	23MS9PH491	Project Part-II	0-0-30	15

Bucket list for elective courses of M.Sc. Physics:

S. No.	Course Code	Course Name	L-T-P	Credit
ELECTIVE-I				
1.	24MSWPH331	Thin Films	3-0-0	3
2.		Microstrip Antenna Design	3-0-0	3
ELECTIVE-II				
3.		Materials Characterization	3-0-0	3
4.		Elements of Nanotechnology	3-0-0	3
ELECTIVE-III				
5.		Compound Semiconductors	3-0-0	3
6.		Advanced Materials Science	3-0-0	3

MATHEMATICAL PHYSICS

COURSE CODE: 23MS1PH101
COURSE CREDITS: 3
CORE/ELECTIVE: Core
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

This course is made with the motivation to teach students with all the fundamental lessons of mathematical methods and their applications for physical problems. The course will not only deal with the mathematical methods required for physics but also teach the applications of the methods for physical problems dealt with physics.

Course Objectives:

The course is designed with the hope to train students about how to solve various mathematical problems encountered in physics.

Course Contents:

Unit	Contents	Lectures required
1	Vector and Tensor: Scalar and vector fields, Vector differential operators: gradient, curl. Divergence and Laplacian. Vector operatorsin curvilinear coordinates. Gauss's theorem. Green's theorem and Stoke's theorem: applications to physical problems. Tensors.	6
2	Boundary value problems: Partial differential equations: applications in electrostatics, Laplace and Poisson equations: heat conduction,diffusion, elastic and electromagnetic waves. Schrodinger wave equation. Solutions in rectangular, sphericalpolar and cylindrical polar coordinates. Boundary conditions.	8
3	Complex Variables: Elements of complex variables. Cauchy-Reimann eqn. Taylor and Maclaurine Expansion, Residue theorem andcontour integration.	10

4	Special Functions: Special functions: Bessel, Hermite, Legendre, Laugerre polynomials: generating functions and orthonormality. Addition theorem for spherical harmonics, application in heat conduction, diffusion, wave equations etc., Diracdelta function and its representations.	**10**
5	Fourier and Laplace Transformations: Fourier analysis. Fourier transforms, Laplace transforms and applications in physics.	**8**
	Total lectures	**42**

Suggested Text Book(s):

1.Mathematical Methods for Physicists: George B. Arfken and Hans-Jurgen

Weber. 2.Mathematics for Physicists and Engineers: Louis A. Pipes.

3.Mathematical Method of Physics: A.K. Ghatak.

Suggested Reference Book(s):

1.Analytical Mathematics in Physics: C. Harper, 1stEdition Prentice Hall

2.Mathematical Physics: B S Rajput

3.Mathematical Method-Potter and Goldberg (Prentice hall of

India) 4.Vector Analysis (Schaum Series) (McGraw Hill)

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

CLASSICAL PHYSICS

COURSE CODE: 23MS1PH102
COURSE CREDITS: 3
CORE/ELECTIVE: Core
L-T-P: 3-0-0

Pre-requisite: None

Course Description and Objectives:

The aim and structure of the course on Classical Mechanics is to train the students of M.Sc. class in the Lagrangian and Hamiltonian formalisms to an extent that they can use these in the modern branches like Quantum Mechanics, quantum Field Theory, Condensed Matter Physics, Astrophysics etc.

Course Contents:

Unit	Contents	Lectures required
1	Lagrangian Formulation: Mechanics of a system of particles; constraints of motion, generalized coordinates, D'Alembert's Principle and Lagrange's velocitydependent forces and the dissipation function, Applications of Lagrangian formulation.	7
2	Hamilton's Principles: Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space andtime and conservation theorems	6
3	Hamilton's Equations: Legendre Transformation, Hamilton's equations of motion,Cyclic-co-ordinates, Hamilton's equations from variational principle, Principle ofleast action.	4
4	Two-body central force problem: Equivalent one body problem, Equation of motion and first integrals, Equivalent one dimensional problem, Classification of orbits, Differential equation for the orbit, Kepler's problem. Differential & total scattering cross-section, Scattering by inverse square law, Rutherford's formula.	7
5	Canonical Transformation and Hamilton-Jacobi Theory: Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton-Jacobi equations for principal and characteristic functions, Harmonic oscillator problem,	7
6	Rigid Body Motion: Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a	7

	rigid body, the inertia tensor.	
7	Small Oscillations: Eigen value equation, Free vibrations, Normal Coordinates, Vibrations of a triatomic molecule.	**4**
	Total lectures	**42**

Suggested Text Book(s):

1. Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi), 3rd ed 2002.

2. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi), 1988.Suggested Reference Book(s):

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

QUANTUM MECHANICS

COURSE CODE: 23MS1PH103
COURSE CREDITS: 3
CORE/ELECTIVE: Core
L-T-P: 3-0-0

Pre-requisite: None

Course Description and Objectives:

Course Contents:

Unit	Contents	Lectures required
1	The principle of Superposition, One and three dimensional wave packets, Motion of wave packets, Differential equation satisfied by wave packets, Interpretation of wavefunction, Probability current density, equation of continuity, wave packet in momentum space, Ehrenfest's theorem, wavepackets and uncertainty relations and spread of wave packet.	**10**
2	Angular Momentum : Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigenvalues and eigenvectors of L2 and Lz. Spin angular momentum, General angular momentum, Eigenvalues and eigenvectors of J2 and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. co-efficients. Wigner-Eckart theorem and its applications. Symmetries, conservation laws, degeneracies	**8**
3	Fundamental postulates of wave mechanics, operator representation of dynamical variables, commutation of operators, Adjoint and hermitian operators, unitary operators, eigen value problem for operators, properties of eigen functions and eigen values of hermitian operators, simultaneous eigen functions, Dirac Delta function and box normalization of free particle wave function, uncertainity principle in operator approach. Bra and ket notations, matrix representation of wave function and operator, energy spectrum of of one dimensional harmonic oscillator using matrix mechanics.	**10**

4	One dimensional finite squarewell potential, particle in one and three dimensional box, solution of free particle Schrödinger equation in spherical polar coordinates, solution of one and three dimensional harmonic oscillator in spherical polar co-ordinate, degeneracy of harmonic oscillator states. Rectangular potential barrier, application of barrier penetration.	**10**
5	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 potentials. Optical theorem, Scattering of identical particles.	**4**
Total lectures		**42**

Suggested Text Book(s):

1. Quantum Mechanics, L. I. Schiff, 3rd Edition, McGraw-Hill (1968).
2. Quantum Mechanics, Ghatak& Loknathan, 1stEdition, MacMillan India
3. Introductory Quantum Mechamics, Richard L. Liboff.
4. Introduction to Quantum Mechanics: C.J. Joachain and B.H. Bransden.
5. Introduction of Quantum Mechanics: D.J. Griffiths.

Suggested Reference Book(s):

1. Quantum Mechanics: Suresh Chandra
2. Quantum Mechanics, Thankapan, 2nd Edition, New Age Int. Ltd (2004).

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

ELECTRODYNAMICS

COURSE CODE: 23MS1PH104
COURSE CREDITS: 3
CORE/ELECTIVE: Core
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

Electromagnetic Theory covers the basic principles of electromagnetism: experimental basis, electrostatics, magnetic fields of steady currents, motional e.m.f. and electromagnetic induction, Maxwell's equations, propagation and radiation of electromagnetic waves, electric and magnetic properties of matter, and conservation laws. This is a graduate level subject which uses appropriate mathematics but whose emphasis is on physical phenomena and principles

Course Objectives:

At master level, the candidate has knowledge beyond an introductory level about - electromagnetic phenomena in vacuum and materials - mathematical methods for analyzing such phenomena. The candidate has knowledge about the concept of conservation laws in electromagnetism. The candidate should be able to solve problems in electromagnetism by applying appropriate mathematical tools and methods, including- vector calculus beyond an introductory level- the method of images, separation of variables and Green functions. The candidate should be able to solve electromagnetic problems numerically. General competence: The candidate should get training in writing a scientific report.

Course Contents:

Unit	Contents	Lectures required
1	Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems Value Problems, Methods of Images, Electrostatic field in Matter-Polarization, bound charges, susceptibility. Formal solution of electrostatic boundary value problems with Green function, Electrostatic potential energy and energy density.	**10**
2	Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance.	**8**

3	Displacement Current; Maxwell Equations, Vector and Scalar Potentials, Gauge Transformations, Lorenz Gauge, Coulomb Gauge, Hertz potential,	**8**
4	Electromagnetic waves in free space. Dielectrics and Dynamics of charged particles in static and uniform electromagnetic fields. Concept of Vector Potential, Magnetic field in matter, Continuity Equation Vector and scalar Potential and Gauge transformation, Pointings Theorem.	**8**
5	Green Functions for the Wave Equation, plane waves in free space and isotropic dielectrics, waves in conducting media, skin depth, Plane waves in a non conducting medium, Reflection and Refraction of Electromagnetic Waves at a	**8**
	Total lectures	**42**

Suggested Text Book(s):

1. Introduction to electrodynamics , David J. Griffiths third edition
2. Classical Electrodynamics , J.D Jackson, third edition
3. Classical Electrodynamics: S.P. Puri (Narosa Publishing House) 2011.
4. Electromagnetic Field Theory Fundamentals: Bhag Singh Guru and H.R. Hiziroglu (Cambridge University Press) 2nd edition, 2004.
5. Introduction to Electrodynamics: A.Z. Capri and P.V. Panat (Narosa Publishing House) 2010.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

EXPERIMENTAL TECHNIQUES

COURSE CODE: 23MS1PH105

COURSE CREDITS: 2

CORE/ELECTIVE: Core

L-T-P: 2-0-0

Pre-requisite: None

Course Description:

This course is designed to aid students in the development of core practical skills in physics. There will be a strong emphasis on data and error analysis. Assessment of reasonable experimental uncertainty in a variety of different measurements, and understood how to minimize that uncertainty.

Course Objectives:

This course seeks to introduce students to basic experimental techniques, measurement theory and experiment design. The primary goal is to develop an appreciation of the role and significance of experimentation in the field of science. Students will be exposed to some widely employed experimental techniques and be introduced to some of the instrumentation that is used in experimental physics research. Students will understand how to critically assess the quality of experimental data and begin to develop their skills in the modeling of experimental data and presenting scientific research.

Course Contents:

Unit	Contents	Lectures Required
1.	**Measurement System:** Methods of Measurements; Functions of Measurement systems; Elements of a generalized measurement system; Example of generalized measurement system; Characteristics of Measuring Instruments; Classification of Errors; Statistical Analysis; Calibration: Process of Calibration; Theory and Principles of Calibration Methods; Standards of measurement; Classification of Standards.	7

2.	**Errors in Measurements and their statistical analysis:** Error analysis, Data interpretation and analysis. Precision and accuracy; propagation of errors; Least squares fitting; Linear and nonlinear curve fitting, chi-square test. Measurement and control. Signal conditioning and recovery.	**7**
3.	**Passive and Active Transducers:** Classification of transducers and characteristics for selection of transducers - Resistive transducers-Strain Gauge, Capacitive transducer - various arrangements, Inductive transducer, LVDT, Passive types: RTD materials & range, relative resistance vs. temperature characteristics, thermistor characteristics, Active type: Thermocouple - characteristics. Piezoelectric active transducer- Equivalent circuit and its characteristics. photo multiplier tube (PMT), photovoltaic, photo conductive cells, photo diodes, phototransistor, Optical displacement sensors and optical encoders	**7**
4.	**Display and recording devices:** Digital Display System and Indicators: Classification of display devices, DOT Matrix display, Digital voltmeter, Multimeter, Digital storage oscilloscope, LCD monitor, PMMC writing systems. Recorders: Graphic recorders, strip chart recorders, Galvanometer type recorders and self-balancing type potentiometric recorders, Magnetic tape recorders and Disc recorders.	**7**
	Total number of Lectures	**28**

Suggested Text Book(s):

1. Error Analysis of Experiments, A Manual, A.F. Mills and B.H. Chang, 2004

2. Introduction To Error Analysis: The Study of Uncertainties in Physical Measurements, John R. Taylor, University Science Books; 2nd edition (1997)

3. Introduction to Error Analysis: The Science of Measurements, Uncertainties, and Data Analysis, Jack Merrin, Createspace Independent Publishing Platform; 1st edition (2017)

4. Principles of Measurement Systems, Bentley John P., Pearson Education India (2007)

5. Transducers Engineering: Principles, Designs and Applications, Dr. Vibhav Kumar Sachan, Smt. Jay Devi Sachan Memorial Publication House; 1st edition (2019)

6. Introduction To Sensors And Transducers, Mr. M.sivasubramanian, Xpress Publications (2022)

7. Electronic Display Devices, Richard A. Perez , McGraw-Hill Education (1988)

Suggested Reference Book(s):

1. Measurements and their Uncertainties: A practical guide to modern error analysis, Ifan

Hughes and Thomas Hase, OUP Oxford; Illustrated edition (2010)

2. Doebelin's Measurement Systems, DOEBELIN, McGraw Hill Education; Sixth Edition (2017)

3. Basic of Transducers: 9 (Krishna), Prof D Sachan, Independently Published (2021)

4. Advanced Display Technology, I B Kang, , C. W. Han, and J K Jeong (EdS), Series in Display Science and Technology, Springer books (2021)

Other useful resources

https://www.youtube.com/watch?v=Atc9vmBX5Po&list=PLFGOC-ueNbIdfq8QjcyzXhMit6eal58N-

https://www.youtube.com/playlist?list=PLFGOC-ueNbIdfq8QjcyzXhMit6eal58N-

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

COMPUTATIONAL PHYSICS

COURSE CODE: 23MS1PH201
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

This course is arranged in such a way that students can learn fundamental numerical methods to solve various problems in physics. The stress is given in theoretical methods for numerical techniques and how to approach various problems in physics to solve numerically,

Course Objectives:

Over the last decades computational techniques have become key to solving complex physical problems in almost all the areas of physics. This course will teach the students about various fundamental computational techniques to implement in physical problems.

Course Contents:

Unit	Contents	Lectures required
1	Errors: its sources, propagation and analysis	3
2	Roots of functions: bisection, Newton-Raphson, secant method, fixed-point iteration, Applications;	6
3	Linear equations: Gauss and Gauss-Jordan elimination, Gauss-Seidel, LU decomposition;	6
4	Eigenvalue Problem: power methods and its applications; Least square fitting of functions and its applications	5
5	Interpolation: Newton's and Chebyshev polynomials; Numerical differentiation: forward, backward and centred difference formulae;	5
6	Numerical integration: Trapezoidal and Simpson's rule, Gauss-Legendre integration, applications; Solutions of ODE: initial value problems, Euler's method, second and fourth order Runge-Kutta methods; Boundary value problems: finite difference method, applications	10
7	Concepts in Computer Programming	6
Total lectures		**42**

Suggested Text Book(s):

1. K. E. Atkinson, Numerical Analysis, John Wiley (Asia) (2004).
2. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill (2002).

Suggested Reference Book(s):

1. Computation Physics: Problem Solving with Python, 3rd Edition by Rubin H. Landau, Manuel J Páez, Cristian C. Bordeianu.
2. Computation in Modern Physics, 3rd Edition by William R. Gibbs
3. Computational Physics Simulation of Classical and Quantum Systems by Philipp O.J. Scherer.
4. Applied Computational Physics by Eric S. Swanson and Joseph F. Boudreau.

Other useful resource(s):

https://www.youtube.com/watch?v=pOtnzAXlXvI&list=PLwdnzlV3ogoUY43XoMwVVCWDSImC9mVQB

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

STATISTICAL PHYSICS

COURSE CODE: 23MS1PH202
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

A transition from thermodynamics to statistical mechanics will be discussed. Statistical mechanics uses theory to determine the distribution of molecular motions and states in a many-molecule system and provides a method to average the states to obtain the macroscopic (bulk) properties. The postulates of classical statistical mechanics, microcanonical, canonical, and grand canonical distributions will be discussed. Applications to lattice vibrations, ideal gas, photon gas, quantum statistical mechanics, Fermi and Bose systems, interacting systems: Cluster expansions, van der Waal's gas, etc will also be discussed.

Course Objectives:

It aims to account for the macroscopic behavior of physical systems in terms of dynamical laws governing the microscopic constituents of these systems and the probabilistic assumptions made about them.

Course Contents:

Unit	Contents	Lectures required
1	Introduction to statistical mechanics. Thermodynamics to statistical mechanics (transition). Ideas of phase space, phase points, Ensemble, Density of phase points. Liouville's equation/theorem. Ensembles: Micro canonical, canonical and grand canonical ensembles. Partition function. Ideal systems: ideal gas, Harmonic oscillators, rigid rotators. Para magnetism.	**6**
2	Density matrix: Quantum mechanical ensemble, application to a free particle in a box, an electron in a magnetic field, beam of spin ½ particles. Distribution functions: Bose-Einstein and Fermi-Dirac statistics: General equations. Gibbs paradox and the Sakur-Tetrode equation	**8**

3	Role of degeneracy in Statistical Mechanics, Thermal de-Broglie wavelength and interparticle sapcing, Quantum degeneracy in energy space. Partition function of an ideal Bose gas; Bose-Einstein condensation and condensate fraction; Equation of state of an ideal Bose gas. Properties of an ideal Fermi Gas: Fermi energy, equation of state, Sommerfeld Expansion, Chemical potential, Specific heat	**10**
4	Interacting system (Strong): Bose-Einstein Condensation of repulsively-interacting bosons using the Hartree approximation and pseudopotential interaction. Gross-Pitaevski equation and Thomas-Fermi solution. Superfluidity in Bose gases. Ising model and exact solution of one-dimensional Ising system.	**10**
5	Phase transitions: Landau theory of phase transitions: First and second order phase transitions,	**8**
	Total lectures	**42**

Suggested Text Book(s):

1. Reif, Frederick, ed. *Fundamentals of Statistical and Thermal Physics*. McGraw-Hill, 1965.
2. Pathria, R. K. *Statistical Mechanics*. Pergamon Press, 1972. ISBN: 9780080189949.

Suggested Reference Book(s):

1. Landau, L. D., and E. M. Lifshitz. Statistical Physics, Part 1. 3rd ed. Pergamon Press, 1980. ISBN: 9780080230382.
2. Huang, Kerson. Statistical Mechanics. 2nd ed. Wiley, 1987.

Other useful resource(s):

https://onlinecourses.nptel.ac.in/noc22_ph22/preview

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus

4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

CONDENSED MATTER PHYSICS-I

COURSE CODE: 23MS1PH203

COURSE CREDITS: 3

CORE/ELECTIVE: CORE

L-T-P : 3-0-0

Pre-requisite: None

Course Contents:

Unit	Contents	Lectures required
1	**Crystal Structure:** Bravais lattices, crystal systems, crystal planes and Miller indices, closed packed structures, symmetry elements in crystals, point groups and space groups, common crystal structures, reciprocal lattice, Ewald construction, Brillouin zone, X-ray diffraction, Bragg's law, Diffraction and the structure factor	8
2	**Band Theory of Solids**: Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power, Free electron gas (theory), density of states, and Fermi Energy, Electron motion in a periodic potential Bloch theorem, Nearly free electron model; tight binding method, Kronnig –Penny model, band theory of solids: metals, insulators and semiconductors	10
3	**Lattice Vibrations**: Elastic properties, Lattice waves, Vibrations of one–dimensional monatomic lattice, Linear diatomic lattice, Three-dimensional lattice, Lattice optical properties in ionic crystal, Quantization of Lattice vibrations, phonons, Lattice specific heat, electronic specific heat.	12
4	**Point defects**: Point defects (Frenkel and Schottky), Lattice vacancies, line defects (slip, plastic deformation, edge and screw dislocation, Burgers vector. Dislocation density, Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order.	7
5	**Superconductivity:** Experimental survey, occurrence, Meissner effect, Critical field, type-I and type-II superconductors;, heat capacity, energy gap, isotope effect. Thermodynamics, Field penetration and London equation, coherence length, BCS theory (qualitative only), BCS ground state. Flux quantization in a superconducting ring, Josephson tunneling, Josephson effect	5
Total lectures		**42**

Suggested Text Book(s):

1. C. Kittel: Introduction to Solid State Physics, VI Edition, (John Wiley and Sons).
2. N. W. Ashcroft and N. D. Mermin: Solid State Physics (H. R. W. International edition).
3. C. A. Wert and R. M. Thomson: Physics of Solids (McGraw Hill)
4. Solid State Physics: A.J. Dekker

Suggested Reference Book(s):

1. Philip Hofmann, Solid State Physics: An Introduction 2nd Edition (2015),
2. J.D. Patterson and B.C. Bailey; Solid State Physics, Springer (2007).
3. M.S. Rogalski and S.B. Palmer; Solid State Physics, Gordon and Breach Science Publishers (2001).

Other useful resource(s):

1. Link to topics related to course:
2. https://archive.nptel.ac.in/courses/115/105/115105099/
3. https://archive.nptel.ac.in/courses/115/104/115104109/

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) - 10 Attendance - 5

ATOMIC AND MOLECULAR PHYSICS

COURSE CODE: 23MS1PH204
COURSE CREDITS: 3
CORE/ELECTIVE: Core
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

The course is designed to give a sound and comprehensive explanation of physics of subatomic entities.

Course Objectives:

To learn laws and functioning of physics at atomic and molecular level to have deeper understanding of our microscopic world.

Course Contents:

Unit	Contents	Lectures required
1	One Electron Atom: Vector model of a one electron atom, Quantum states of an electron inan atom, Hydrogen atom spectrum, Spin-orbit coupling, Relativistic correction, Hydrogenfine structure, Spectroscopic terms, and Hyperfine structure.	11
2	Two valance Electron Atom: Vector model for two valance electrons atom, LS coupling,Pauli Exclusion Principle, Interaction energy for LS coupling, Lande interval rule, jj coupling,interaction energy for jj coupling.	11
3	Atom in Magnetic Field: Zeeman Effect, Magnetic moment of a bound electron, Magneticinteraction energy in weak field. Paschen-Back effect, Magnetic interaction energy in strongfield	8
4	Molecular Spectroscopy: Rotational and vibrational spectra of diatomic molecule, Raman Spectra, Electronic spectra, Born-Oppenheimer approximation, Vibrational coarse structure, Franck-Condon principle,Rotational fine structure of electronic-vibration transitions. Electron spin and nuclear magnetic resonance spectroscopy.	12
Total lectures		**42**

Suggested Text Book(s):

1. White, H.E., Introduction to Atomic Spectra, McGraw Hill, (1934).
2. Banwell, C.N. and McCash, E.M., Fundamentals of molecular spectroscopy, Tata McGraw Hill, (2007)

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

ELECTRONICS

COURSE CODE: 23MS1PH205
COURSE CREDITS: 3
CORE/ELECTIVE: Core
L-T-P : 3-0-0

Pre-requisite: None

Course Description:

Electronics is composed of physics, engineering, technology and applications. The field of electronics deals with the emission, flow and control f electrons in vacuum and matter. Electronic use active devices to control electron flow by amplification and rectification. Electronics distinguishes itself from classical electrical engineering that uses passive effects like resistance, capacitance and inductance to control current flow.

Course Objectives:

1. To provide a comprehensive understanding of electronic devices and circuits
2. To understand the working semiconductor devices for different applications
3. To study basic circuits for designing the feedback amplifiers, oscillators
4. To study high power electronic components

Course Contents:

Unit	Contents	Lectures required
1	Basics of Semiconductor devices. diodes, transistors, field effect devices, homo- and hetero-junction devices, device structure, device characteristics, frequency dependence and applications	**10**
2	Opto-electronic devices (solar cells, photo-detectors, LEDs)	**4**
3	Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback)	**10**
4	A/D and D/A converters. Microprocessor and microcontroller basics. Data interpretation and analysis	**6**
5	Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors).	**5**
6	Measurement and control, filtering and noise reduction, Fourier transforms Modulation techniques. High frequency devices.	**7**
Total lectures		**42**

Suggested Text Book(s):

1. Electronics devices & Circuits, Jacob Millman and Christos Halkias, Tata Mcgraw Hill Publications.

2. Integrated Electronics, Jacob Millman, Christos Halkias and Chetan Pariek, Tata Mcgraw Hill Publications.

3.Digital Principle and Application by, A. P. Malvino and Donald P. Leach, TMH, New Delhi .

4.Op-amp and Linear Integrated Circuit by Ramakanth A. Gayakwad,sss PHI, New Delhi.

Suggested Reference Book(s):

1 Microprocessor Architecture, programming and Applications with 8085/8086 by Ramesh S. Gaonkar, Wiley – Eastern Let.

2. Electronic communication system by G. Kennedy and B. Davis, TMH, New Delhi

3. Semiconductor Devices by S. M. Sze . JWS,

Other useful resource(s):

https://onlinecourses.nptel.ac.in/noc21_ee55/preview
https://nptel.ac.in/courses/122106025

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) -10 Attendance - 5

ELECTRONICS II

COURSE CODE: 18MS1PH311
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

This course will provide a basic knowledge of digital electronics necessary for future

Course Objectives:

To build up on the basic knowledge of electronics with the introduction of advanced topics like circuit analysis and applications of semiconductor devices in analog and digital circuits.

Course Contents:

Unit	Contents	Lectures required
1	Boolean algebra; Logic gates	**3**
2	De-Morgan's theorem; Logic Families: TTL, MOS and CMOS;	**7**
3	Combinational Circuits: Adders, subtractors, Encoder, De-coder, Comparator, Multiplexer, De-multiplexers, Parity generator and checker	**8**
4	Sequential Circuits: Flip-flops, Registers, Counters, Memories; A/D and D/A conversion	**6**
5	Architecture and programming; I/O interfacing using PPI 8255 and 8155; Architectural evolution in 16-bit, 32-bit and 64-bit microprocessors.	**6**
6	Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting	**12**
Total lectures		**42**

Suggested Text Book(s):

1. Integrated Electronics; Analog and Digital circuits, by Jacob Millman and Christos C. Halkias.
2. Fundamentals of Electric Circuits, by Charles K. Alexander (Author) and Matthew N.O. Sadiku.

Suggested Reference Book(s):

1. Digital Design by M.Morris Mano.
2. Fundamentals of Logic Design by Charles H.Roth.
3. Digital Design by John F. Wakerly.

Other useful resource(s):

https://youtu.be/oNh6V91zdPY?si=u7vXlviPFY4VRQJY

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

CONDENSED MATTER PHYSICS-II

COURSE CODE: 18MS1PH313
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

Condensed-matter physics II is the study of the properties of substances in their solid state. This includes the investigation of their magnetic, dielectric, transport properties, etc. Various theories related to their performance are studied in detail.

Course Objectives:

To understand the various atom and electron interactions and how the physical properties in matter are evolving due to these interactions.

Course Contents:

Unit	Contents	Lectures required
1	Magnetism: Basic ideas; introduction to diamagnetism and quantum theory of paramagnetism. Theories of Ferromagnetism, Weiss and Heisenberg Model - Conditions for Ferro- and Antiferro- Magnetic Order, Spin Waves and Magnons, Bloch's $T^{3/2}$ Law, Antiferromagnetic Order, Neel Temperature Diluted Magnetic Semiconductors: Elementary Concepts.	**8**
2	Ferroelectricity: Ferroelectric Crystals, Classification of Ferroelectric Crystals, Polarization Catastrophe, Soft Optical Phonons, Landau Theory of Phase Transition - Second and First Order Transition. Multiferroics: Elementary Concept.	**8**
3	Dielectrics: Polarization mechanism & Dielectric Constant, Behavior of polarization under impulse and frequency switching, Dielectric loss, Spontaneous polarization, Piezoelectric effect; Applications of Dielectric Materials.	**8**
4	Transport Properties: The Boltzmann Equation, Electrical Conductivity, General Transport Coefficients, Thermal Conductivity, Thermoelectric Effect, Hall Effect, Elementary Ideas on Quantum Hall Effect, Magnetoresistance, Elementary Ideas	**8**

	of Giant Magneto-Resistance and Colossal Magneto-Resistance.	
5	New Engineering Materials: Metallic Glasses, Shape Memory Alloys, Memory Effect, Nano-materials- significance of 2anoscale, 0-Dimensional, 1-Dimensional, 2-Dimensional, 3- Dimensional nanostructures, Applications.	**8**
6	Semiconductor junctions and ideality factor; Polymer synthesis, properties and applications; Ceramic properties and applications	**4**
	Total lectures	**42**

Suggested Text Book(s):

(1) Introduction to Solid State Physics, C. Kittel
(2) Elementary Solid State Physics, M.A. Omar
(3) Text Book of Nanoscience and Nanotechnology, B. S. Murty, P. Shankar, B. Raj, B. B. Rath and J. Murday

Suggested Reference Book(s):

(1) Solid State Physics, Aschroft, Mermin
(2) Science of Engineering Materials and Carbon Nanotubes: C. M. Srivastava & C. Srinivasan

Other useful resource(s): Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) -10 Attendance - 5

NUCLEAR AND PARTICLE PHYSICS

COURSE CODE: 24MS1PH311
COURSE CREDITS: 3
CORE/ELECTIVE: CORE
L-T-P: 3-0-0

Pre-requisite: None

Course Description: This is an introductory graduate-level course on the phenomenology and experimental foundations of nuclear and particle physics, including the fundamental forces and particles, as well as composites. Emphasis is on the experimental establishment of the leading models, and the theoretical tools and experimental apparatus used to establish them.

Course Objectives: The objective of the course is to impart knowledge about basic nuclear physics properties and nuclear models for understanding of related reaction dynamics and basic concepts and fundamental principles of particle physics.

Course Contents:

Unit	Contents	Lectures required
1	Introduction to Nuclear Physics: General Properties of nuclei; Nuclear nomenclature; Binding energy and semi-empirical mass formula;; Radioactive decay	**8**
2	Nuclear Structure; Characteristics of the nuclear force; The deuteron; Nuclear models; Gamma decay; Beta decay	**8**
3	Scattering and tunneling in quantum mechanics; Alpha decay, Bound problems; Identical particles; Interaction of radiation with matter: Fusion Fission	**8**
4	Introduction to Particle Physics; Fundamental particles and their searches, Accelerators and Colliders; Basic interactions; Relativity; antiparticles; Rotation, Isospin, Addition of Angular momentum; Conservation laws in decays and scattering	**10**
5	Gauge Symmetries: U(1), SU(2) and SU(3) local gauge invariance; Yang Mills Lagrangian Symmetry Breaking: explicit and spontaneous; Goldstone Theorem; Higgs Mechanism; Quark Model	**8**
Total lectures		**42**

Suggested Text Book(s):

1. The Atomic Nucleus by R.D. Evans
2. Krane, Kenneth S. Introductory Nuclear Physics. 3rd ed. John Wiley & Sons.
3. Griffiths, David J. Introduction to Elementary Particles. Wiley-VCH, 2017.
4. Perkins, Donald H. Introduction to High Energy Physics. Cambridge University Press, 2014. Griffiths, David J. Introduction to Elementary Particles. Wiley-VCH, 2017.

Suggested Reference Book(s):

1. Nuclear and Particle Physics, By W.E. Burcham
2. Thomson, Mark. Modern Particle Physics. Cambridge University Press, 2013. ISBN: 9781107034266

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) -10 Attendance - 5

ADVANCED QUANTUM MECHANICS

COURSE CODE: 18MS1PH312
COURSE CREDITS: 3
CORE/ELECTIVE: Core
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

Once, quantum mechanics was most demanding for physicsists now a days it had become essential to solve complex and real word problems. This course is intended to cover most of the advance topics in quantum mechanics, including postulates, approximation and perturbations, spin angular momentum, operator methods, interaction of charged particles with a classical.

Course Objectives:

This course is intended to provide an enhanced level understanding of quantum mechanics. By the end of the course, the students should be able to:

1. Utilize the postulates of quantum mechanics to describe quantum systems and determine their properties, including the results of measurements.

2. Use operator techniques to solve relevant problems.

3. Analyze the time dependence of quantum systems using the perturbation thoery.

4. Use the properties of angular momentum and spin to describe quantum systems such as the hydrogen atom and an electron in a magnetic field.

5. Understand the interaction of the electromagnetic field with charged quantum mechanical particles and solve related problems such as the rate of absorption and emission of light.

6. Use perturbation theory to find approximate solutions to more complex quantum mechanical systems.

Course Contents:

Unit	Contents	Lectures required
1.	**Perturbation Theory :** Time independent non-degenerate perturbation theory upto second order. Applications to normal He atom, perturbed harmonic oscillator. Time independent degenerate perturbation theory upto first order. Application of degenerate perturbation theory to stark effect and Zeeman effect. Time dependent perturbation theory, calculation of 1st order transition amplitude, transition probability, and derivation of Fermi Golden rule.	**10**
2.	**Quantum Mechanical theory of spin:** 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, Lambshift. Hyperfine structure, electron-electron , electron nucleus interaction.	**12**
3.	**Scattering Theory-I:** Semi Classical theory of radiations, Einstein's coefficients of emission and absorption, expression for transition probability for absorption and induced emission using electric dipole approximation. Adiabatic approximation for solving time dependent problems, sudden approximation. Variational technique, its application to ground state of He, atom. W.K.B-approximation, classical turning points, connection formulae, Application to WKB to bound state problem and tunneling.	**8**
4.	**Scattering Theory-II:** Differential and total scattering cross sections, scattering amplitude, relation between differential scattering cross section and scattering amplitude, Laboratory and centre of mass reference frames,relations of scattering angles and cross sections in laboratory and centre of mass reference frames. Partial wave analysis, expression for scattering amplitude and total scattering cross section in terms of phase shifts, scattering by perfectly rigid sphere and by square well potential, Deduction of optical theorem for scattering cross section.	**12**
	Total number of Lectures	**42**

Suggested Text Book(s):

1. Absorption and Scattering of light by Bohren and Huffman
2. Advance Quantum theory by Claude Cohen and Tanndoudjji
3. Advance Quantum Mechanics J.J Sakurai

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

THIN FILMS

COURSE CODE: 24MSWPH331
COURSE CREDITS: 3
CORE/ELECTIVE: Elective
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

Thin film research is an interdisciplinary topic. This course gives a student exposure to thin film fundamentals and processing.

Course Objectives:

After completion of this course, the students should be able to deposit thin layers that will have certain desired attributes, which can be specifically adapted for state-of-the-art applications. Also, familiarization with various growth models and instrumentation techniques is the second purpose.

Course Contents:

Unit	Contents	Lectures required
1	Fick's Laws, Diffusion coefficients, Arrhenius equation, Nucleation and Growth: Homogeneous nucleation, critical radius, nucleation rate, Film formation, Capillarity model (heterogeneous nucleation), Effects of supersaturation, temperature, lattice strain, impurity, surface imperfections, Coalescence, incorporation of defects, impurities in films, Film formation, Growth modes, island growth, zone models, columnar growth, Deposition parameters and their effects on film growth	15
2	Production of low pressure, Vacuum pumps, Cryo-pumping, Gettering, Measurement of pumping speed, thermal conductivity gauges (Pirani and Penning), Cleaning techniques, sealing techniques, Leak detection, rules for operating vacuum systems	8
3	Thin film deposition basics. Deposition technology such as thermal evaporation, electron beam, flash sputtering (DC, RF, cathodic, glow discharge, magnetron, reactive, ion-assisted, ion sources, ion etching), chemical vapour deposition (reaction types, boundaries, and flow) (LPCVD, PECVD, LECVD, MOCVD),	10

	chemical bath deposition (electrodeposition, Anodic oxidation, electrolysis plating, deposition by chemical reaction, chemical displacement), Molecular beam epitaxy)	
4	Other thin film deposition techniques: Sol-gel, drop casting, atomic layer deposition, screen printing, dip coating, etc.	**4**
5	Substrate surface and thin film nucleation; Introduction to clean room processing for thin film-based devices; lithography.	**5**
	Total lectures	**42**

Suggested Text Book(s):

1. Thin Films Phenomenon by K.L. Chopra, Krieger
2. Thin Film Fundamentals by A Goswami, New Age International
3. Thin Films Technology, Alexander Axelevitch, World Scientific, 2021.

Suggested Reference Book(s):

1. Material Science of Thin Films, Deposition and Structure by Milton Ohring, Elsevier, Second Edition, 2002.
2. Physical Vapor Deposition of Thin Films, John E. Mahan, John Wiley & Sons
3. Recent Advances in Thin Films, Sushil Kumar, D. K. Aswal, Springer Singapore, 2020.

Other useful resource(s):

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

MICROSTRIP ANTENNA DESIGN

COURSE CODE:
COURSE CREDITS: 3
CORE/ELECTIVE: Elective
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

The microstrip patch configuration is widely used in many antenna applications such as 5G, V2X, and ADAS. In this video we will discuss the configuration of a microstrip patch antenna. We will provide a detailed explanation of the radiation of a patch antenna due to fringing fields. Polarization and types of polarization are also discussed. Various parameters of microstrip patch antennas, their effects on performance, and design considerations are also discussed.

Course Objectives:

1. Provide an introduction to microstrip antennas.
2. Provide a physical and mathematical basis for understanding how microstrip antennas work.
3. Provide a physical understanding of the basic physical properties of microstrip antennas.
4. Provide an overview of some of the recent advances and trends in the area (but not an exhaustive survey – directed towards understanding the fundamental principles).

Course Contents:

Unit	Contents	Lectures Required
1.	Antenna Fundamentals: Definitions, Simple Radiating Systems, Analysis of Antenna Arrays , Radiation Pattern Synthesis using Arrays, Line Sources	8
2.	Wire Antennas: Dipoles, Yagi-Uda Array, Loop Antenna, Traveling Wave Antennas, Broadband Antennas	8
3.	Microstrip Antennas: Microstrip Antenna Patterns, Microstrip Patch Bandwidth and Surface-Wave Efficiency, Rectangular Microstrip Patch Antenna, Quarter-Wave Patch Antenna	8
4.	Circular Microstrip Patch: Circularly Polarized Patch Antennas, Compact Patches, Directly Fed Stacked Patches, Aperture-Coupled Stacked Patches	9

5.	Patch Antenna Feed Networks: Series-Fed Array, Microstrip Dipole, 330 6-13 Microstrip Franklin Array, Microstrip Antenna Mechanical Properties	9
	Total Lectures	**42**

Suggested text Book(s):

1. J. L. Volakis, "Antenna Engineering Handbook", 4th ed. New York: McGraw Hill, 2007.

2. J. B. H. Nielesen, P. K. Malik and S. K. padmnaban, Microstrip Antenna Design for Wireless Applications, 1st ed., CRC Press, 2021.

3. R. Bancroft, Microstrip And Printed Antenna Design, Scitech Pub. Inc., 2009.

Suggested Reference Book(s):

1. K. P. Jasmine, K. N. Prakash, Design and analysis of Microstrip Antennas, LAP Lambert Academic Publishing, 2020.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

MATERIALS CHARACTERIZATION

COURSE CODE:
COURSE CREDITS: 3
CORE/ELECTIVE: Elective
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

Characterization of materials is essential to the systematic development of new materials and understanding how they behave in practical applications. This course focuses on the principal methods required to characterize broad range of materials such as metal, alloys, semiconductors, insulators, polymers, ceramics, nanostructures etc. for their applications based on mechanical, electrical, optical, magnetic, thermal properties of materials. The topics covers structure analysis tools, microscopy techniques, thermal analysis technique, electrical characterization, magnetic characterization, and optical spectroscopy, and other techniques for characterization of materials.

Course Objectives:

The aim of this course is to provide introductory understanding of number important techniques in terms of the instrumentation, working principles, and information obtained and possible analysis of the materials. This course is targeted towards undergraduate and postgraduate students of physics, materials science, metallurgy, energy technology, electrical engineering and electronics, polymer science and engineering etc. Contents: Introduction to materials and Techniques.

Course Contents:

Unit	Contents	Lectures required
1	**Structure analysis tools:** X-ray diffraction: phase identification, indexing and lattice parameter determination, Analytical line profile fitting using various models, Neutron diffraction **Surface analysis tools:** UV and X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), Low energy electron diffraction (LEED) and reflection high energy electron diffraction (RHEED), Secondary ion mass spectrometry (SIMS), Rutherford Backscattering (RBS), Medium energy ion scattering, Electron energy loss spectroscopy (EELS) and high resolution EELS	8
2	**Nanoscale Electrical Spectroscopy:** I-V/C-V, Hall, quantum Hall, fractional quantum Hall effects, Transient charge spectroscopy.	6

3	**Optical spectroscopy**: Optical and electronic characterization techniques: UV-VIS Photoluminescence spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy.	7
4	**Imaging and Local Spectroscopy** : Optical microscopy, transmission electron microscopy (TEM), energy dispersive X-ray microanalysis (EDS), scanning electron microscopy (SEM), Rutherford backscattering spectrometry (RBS), atomic force microscopy (AFM) and scanning probe microscopy (SPM	7
5	**Thermal analysis technique:** Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermogravimetric analysis (TGA);Electrical characterization techniques: Electrical resistivity, Hall effect, Magnetoresistance	7
6	**Magnetic characterization techniques:** Introduction to Magnetism, Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method, Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance	7
	Total lectures	**42**

Suggested Text Book(s):

1. Characterization of Materials (Materials Science and Technology:A Comprehensive Treatment, Vol 2A & 2B, VCH (1992).

2. Semiconductor Material and Device Characterization, 3rd Edition, D.K.Schroder, Wiley-IEEE Press (2006).

3. Materials Characterization Techniques,S Zhang, L. Li and Ashok Kumar, CRC Press (2008).

4. Physical methods for Materials Characterization,P.E. J. Flewitt and R K Wild, IOP Publishing (2003).

Suggested Reference Book(s):

1. Willard, “Instrumental Methods of Analysis”, Van Nostrand, 2000

2. J. Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lyman et.al, Scanning Electron Microscopy and X-ray Microanalysis, Springer Publications, 2003.

3. P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, Taylor and Francis, 2001

4. Zhong Lin Wang, Characterization OfNanophase Materials, Wiley-VCH, Verlag GmbH, Germany (2004).

5. W.R. Fahrner, Nanotechnology and Nanoelectronics Materials, Devices, Measurement Techniques, Springer-Verlag Berlin, Germany (2006).
6. Hans P.O., and Hopster H., ―Magnetic Microscopy of Nanostructuresљ, Springer (2004)
7. Vladimir G. Bordo and Horst-Günter Rubahn; Optics and Spectroscopy at Surfaces and Interfaces, John-Wiley and Sons, Inc., (2005).
8. William W. Parson, Modern Optical Spectroscopy, Springer, (2007).
9. Francis Rouessac and AnnickRouessac, Chemical Analysis-Modern Instrumentation Methods and Techniques, (2000).
10. Joseph. R. Lakowicz Principles of fluorescence spectroscopy, Springer, (2010).
11. Pavia Lampman, Kriz, Vyvyan, Introduction to spectroscopy, Cengage learning, (2009).
12. Jin JhongJhang, Optical properties and spectroscopies of Nanomaterials, World Scientific Publishing (2009).
13. D. K. Schroder, Semiconductor Material and Device Characterization, 3rd Edition, WileyIEEE Press (2006).
14. S Zhang, L. Li and Ashok Kumar, Materials Characterization Techniques, CRC Press (2008).
15. P. E. J. Flewitt and R K Wild, Physical methods for Materials Characterization, IOP Publishing (2003).
16. Jin Zhong Zhang, Optical properties and spectroscopy of Nanomaterials, World Scientific Publishers (2009).
17. M Joshi et al, Characterization techniques for Nanotechnology applications in Textiles, Indian Journal of Fibre and Textile Research, Vol 33, 304-317 (2008).
18. Peter Torok, Fu-Jen Kao (Eds.), Optical Imaging and Microscopy: Techniques and Advanced Systems, Springer Series in Optical Sciences, Springer, 2nd Edition, (2007).
19. GuoJinghua (Ed.), X-rays in Nanoscience - Spectroscopy, Spectromicroscopy, and Scattering Techniques, John Wiley & Sons (2010).

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes (2) -10 Attendance - 5

ELEMENTS OF NANOTECHNOLOGY

COURSE CODE:
COURSE CREDITS: 3
CORE/ELECTIVE: Elective
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

The famous statement by eminent scientist R.P. Feynman: There is a plenty of room at the bottom is the driving force of the proposed course. The concept of Nanotechnology enlightens a new world of possibilities towards a variety of Industries and Scientific accomplishments. Nanotechnology deals in the molecular or sub-molecular scale, where the manipulation of material properties may be possible because both classical and quantum effects can be active, leading to unique properties of nano devices. Nanotechnology builds up with the inter-disciplinary approach expertise in different technology domains (e.g. Cosmetics to Construction, Entertainment to Environment, and Mobile to Medical). The course is designed for beginners to apprehend the fundamentals, properties, and applications of Nanotechnology and Nanomaterials in various fields. The background required for the course is a basic understanding of Physics, Chemistry, Biology, and Engineering.

Course Objectives:

The specific goals of the course are categorized as follows:

i) To provide a critical and systematic understanding of cutting-edge technology at the forefront: from Electronics to Medical Science, Cosmetics to Construction and Entertainment to Environment.

ii) An overall concept regarding the prominence of Nanomaterials and its classification, synthesis process, different approaches: Top-down and Bottom-up, and modern instrumental techniques suited to the characterization of the micro/nano-structural properties.

iii) The commercial applications of Nanotechnology.

Course Contents:

Unit	Contents	Lectures required
1	Background to Nanotechnology: Scientific revolution;Atomic structures; Molecular and atomic size-Bohr radius; Emergence of Nanotechnology; Challenges in Nanotechnology; Carbon age–New form of carbon (from Graphene sheet to CNT).	**4**
2	Nucleation : Influence of nucleation rate on the size of the crystals; macroscopic to microscopic crystals and nanocrystals; large surface to volume ratio, top-down and bottom-up approaches-self assembly process;- grain boundary volume in nanocrystals; defects in nanocrystals; surface effects on the properties.	**8**
3	Types of Nanostructures : Definition of a Nano system ; Types of Nanocrystals: One Dimensional (1D); Two Dimensional (2D); Three Dimensional (3D) nanostructured materials; Quantum dots ; Quantum wire, Core/Shell structures.	**10**
4	Nanomaterials and properties: Carbon Nanotubes (CNT) :Metals (Au, Ag); Metal oxides (TiO_2, CeO_2, ZnO); Semiconductors (Si, Ge, CdS, ZnSe); Ceramics and Composites; Dilute magnetic semiconductor; Biological system: DNA and RNA ; Lipids ; Size dependent properties; Mechanical, Physical and Chemical properties.	**10**
5	Applications of Nanomaterials: Medicine and Healthcare Applications; Biological and Biochemical Applications (Nano biotechnology); Electronic Applications (Nano electronics); Computing Applications (Nanocomputers), Chemical Applications (Nano chemistry); Optical Applications (Nano photonics); Agriculture and Food Applications; Recent Major Breakthroughs in Nanotechnology.	**10**
	Total lectures	**42**

Suggested Text Book(s):

1. M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Nanotechnology: Basic science and Emerging technologies, Overseas Press India Pvt Ltd, New Delhi, First Edition, 2005.
2. Kenneth J. Klabunde (Eds), Nanoscale Materials Science, John Wiley & Sons, InC, 2001.
3. C.S.S.R.Kumar, J.Hormes, C.Leuschner, Nanofabrication towards biomedical applications, Wiley – VCH Verlag GmbH & Co, Weinheim, 2004.
4. W. Rainer, Nano Electronics and information Technology, Wiley, 2003.

5.Nano Materials –A.K. Bandyopadhyay/ New Age Publishers

5. Nanocrystals: Synthesis, Properties and Applications –C.N.R. Rao, P. John Thomas and G. U. Kulkarni, Springer Series in Materials Science

6. Nano Essentials-T. Pradeep/TMH

7. Peter J. F. Harris, Carbon nanotube science: synthesis, properties, and applications. Cambridge University Press, 2011

8. 5.M.A. Shah, K.A. Shah, "Nanotechnology: The Science of Small", Wiley India, ISBN 13: 9788126538683

Suggested Reference Book(s):

1. K.E.Drexler, Nano systems, Wiley, 1992. 7. G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, 2004.
2. C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH Verlag Gmbh&Co, Weinheim, 2004.
3. Nanomaterials: An introduction to synthesis, properties and application, Dieter Vollath, WILE-VCH, 2008
4. Introduction to Nanotechnology, C. P. Poole and F. J. Owens, Wiley, 2003
5. Understanding Nanotechnology, Scientific American 2002
6. Nanotechnology, M. Ratner and D. Ratner, Prentice Hall 2003
7. Nanotechnology, M. Wildon, K. Kannagara, G. Smith, M. Simmons and B. Raguse, CRC Press Boca Raton 2002

Evaluation Scheme:

S. No	**Exam**	**Marks**	**Duration**	**Coverage / Scope of Examination**
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

COMPOUND SEMICONDUCTORS

COURSE CODE:
COURSE CREDITS: 3
CORE/ELECTIVE: Elective
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

Compound semiconductors have become extremely important in modern technology. Many electronic and optoelectronic devices like light emitting diodes, lasers, high-frequency heterojunction transistors, high electron mobility transistors and high voltage power switching devices are based on compound semiconductors like GaAs, InP, GaN and SiC. These devices are also envisioned to be key enablers in future applications like high-speed data communication, efficient power transmission, electric vehicles, autonomous driving, internet of things etc. This course will cover the device physics of compound semiconductors mainly focusing on electronic devices like heterojunction bipolar transistors, high electron mobility transistors and high voltage transistors.

Course Objectives:

The specific goals of the course are categorized as follows:

1. Be able to understand requirements of compound semiconductors
2. Be able to understand basic physics of compound semiconductors
3. Be able to understand basic mechanism of compound semiconductor devices

Course Contents:

Unit	Contents	Lectures required
1	Band theory of solids: Free electron theory, Kronig-Penny model, Band formation in solids, Introduction to "real" (defect-containing) solids, equilibria and kinetic processes in solids. Doping in solids.	12
2	Crystalline Semiconductors: Growth, Diffusion, ion implantation, oxidation, microlithography, plasma etching, thin film deposition, metallization, with emphasis on Si technology. Introduction to compound semiconductors, Characterization by X-ray diffraction, Differential scanning calorimetry, Scanning electron microscopy. I-V characteristcs and optical absorption. Process integration for GaAs IC's.	12

3	Non-crystalline Semiconductors: Phase diagrams, Formation of inorganic semiconductor glasses. Viscosity and structural relaxation. Phase separation and crystallization. Characterization by DTA, XRD, SEM. I-V characteristics, Optical absorption and photoconducting properties.	**12**
4	Advanced materials: Si, GaAs, InP,– synthesis, charaterization and properties.	**6**
	Total lectures	**42**

Suggested Text Book(s):

1. Compound Semiconductor Device Physics (The Open Edition) Sandip Tiwari Original Publisher: ACADEMIC PRESS
2. Compound Semiconductors Physics, Technology, and Device Concepts by Ferdinand Scholz, Jenny Stanford Publishing
3. Compound Semiconductors by Ferdinand Scholz, Published by Pan Stanf

Suggested Reference Book(s):

1. Solid State Physics: C. Kittel, Introduction to solid state physics (any edition), John Wiley
2. Semiconductor physics and devices: S. Wang, Fundamentals of semiconductor theory and device physics, Prentice Hall, 1989
3. Quantum Wells and Heterostructures: J. H. Davies,
4. Physics of low-dimensional semiconductors, Cambridge, 1998
5. Quantum semiconductor structures, Academic Press, C. Weisbuch and B. Vinter, 1991
6. Compound Semiconductor Materials: V. Swaminathan and A.T. Macrander,
7. Materials Aspects of GaAs and InP based structures, Prentice Hall, 1991
8. Basic Semiconductors: Free online textbook, see: http://ecee.colorado.edu/~bart/book/contents.htm, Prof. Bart Van Zeghbroeck, University of Colorado

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5

ADVANCED MATERIALS SCIENCE

COURSE CODE:
COURSE CREDITS: 3
CORE/ELECTIVE: Elective
L-T-P: 3-0-0

Pre-requisite: None

Course Description:

This course explores materials and materials processes from the perspective of thermodynamics and kinetics. The thermodynamics aspect includes laws of thermodynamics, solution theory and equilibrium diagrams. The kinetics aspect includes diffusion, phase transformations, and the development of microstructure.

Course Objectives:

1. Use the fundamental science and engineering principles relevant to materials that include the relationships between nano/microstructure, characterization, properties, processing, performance and design of materials.
2. Use their knowledge of the significance of research, the value of continued learning and environmental/social issues surrounding materials.
3. Use the technical and communication skills developed in the program as a foundation for careers in engineering, research and development, the pursuit of advanced education and other professional careers.
4. Use lifelong learning skills to develop knowledge and skills, to pursue new areas of expertise and careers, and to take advantage of professional development opportunities.

Course Contents:

Unit	Contents	Lectures Required
1.	**Introduction:** Structure, defects in solids, bonds and bands in materials, thermodynamics in materials, kinetics, nucleation and growth, coalescence, coagulation and size distributions.	8
2.	**Semiconductor Basics**: Crystalline and Non-Crystalline Semiconductors, Fermi level, carrier concentration, mobility, conductivity, p-n junctions-band diagram, forward and reverse I-V characteristics, C-V, transistor-basic concepts, Doping in solids	8
3.	**Growth Techniques:** Sputtering, MBE, CBD, CVD, PECVD, oxidation, microlithography, plasma etching, thin film deposition, metallization,	8

4.	**Magnetic Materials:** Magnetostatics, magnetism of electrons (all types), nanoscale magnetism, spin electronics and magnetic recording, Applications	**6**
5.	**Electronic Materials:** Electrical properties of polymers, ceramics, dielectrics, and amorphous materials Optical materials and their properties.	**6**
6.	**Applications:** Xerography, Holography, photolithography, Solid State batteries, radiation sensors and measuring devices, Waveguides, IR devices etc.	**6**

Suggested Text Book(s):

1. Ajit Behera, Advanced Materials: An Introduction to Modern Materials Science, Springer Nature Switzerland AG; 1st ed. 2022.
2. N. Chaudhary, D. H. Panwar, T. R. Prajapati ,Chemistry of Advanced Materials, Pinakin Publishing, 2024.
3. Janet Taylor, Materials, Cambridge University Press, 2002.

Suggested Reference Book(s):

1. S Rafi Ahamed and P Manikandan, Advanced Materials Science, LAP Lambert Academic Publishing, 2020.
2. Marc J. M. Abadie, Omari V. Mukbaniani, et al, Science and Technology of Polymers and Advanced Materials, Apple Academic Press Inc.; 1st edition, 2021.

Evaluation Scheme:

S. No	Exam	Marks	Duration	Coverage / Scope of Examination
1	T-1	15	1 Hour.	Syllabus covered upto T-1
2	T-2	25	1.5 Hours	Syllabus covered upto T-2
3.	T-3	35	2 Hours	Entire Syllabus
4.	Teaching Assessment	25	Entire Semester	Assignment (2) - 10 Quizzes(2) -10 Attendance - 5