MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT501	**Classical Mechanics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)

This course aims to introduce the Lagrangian and Hamiltonian formalism of Newtonian Mechanics, action principle, symmetries and conservation laws. The course will also cover Hamilton-Jacobi theory and four-vector formalism of special theory of relativity.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Introduction and motivation, Mechanics of a system of particles, constraints and their classifications, virtual work and D'Alembert's principle, generalized coordinates, Lagrange's equation and its application, velocity dependent potentials and the dissipation function, calculus of variations, Hamilton's principle, Lagrange's equations from Hamilton's principle. Method of Lagrange's multipliers for nonholonomic systems, cyclic coordinates, conservation theorems and symmetry principles, Noether's theorem, Jacobi's integral.

(No. of lectures: 12)

Applications of Lagrangian formalism: central forces, Kepler's problem, Laplace-Runge-Lenz vector, virial theorem, scattering from a central force field in center of mass and laboratory coordinate systems, rigid body kinematics, orthogonal transformations, Eulerian angles, Euler theorem, Finite and infinite rotations, uniformly rotating frames, Coriolis force, force free motion of a rigid body small oscillations and normal modes. Free vibrations of a triatomic molecule.

(No. of lectures: 14)

Legendre Transformations and the Hamilton equations of motion, Routh's Procedure, derivation of Hamilton's equations from a variational principle, canonical transformations, examples of canonical transformations, phase space diagram, stability analysis, Poisson brackets, Liouville's Theorem Hamilton Jacobi theory.

(No. of lectures: 8)

Lorentz transformations, Minkowski spacetime, intervals, light cone, four-vector formalism, metric tensor, contravariant and covariant tensor, covariant Lagrangian and Hamiltonian formulation**,** four vector formalism of electrodynamics.

(No. of lectures: 5)

Recommended Readings

Text books –

1. Classical Mechanics –Goldstein, Poole and Safko (Pearson Education).
2. Classical Mechanics – N. C. Rana and P. S. Joag (Tata McGraw Hill).
3. Introduction to Electrodynamics, David J. Griffiths

Reference books –

1. Mechanics – L. D. Landau and E. M. Lifshitz (Pergamon Press, Oxford).
2. Classical theory of fields L. D. Landau and E. M. Lifshitz (Pergamon Press, Oxford).
3. Classical Mechanics: Kibble and Berkshir (World Scientific)
4. Introduction to Classical Mechanics with Problems and Solutions: David Morin (Cambridge University Press).

Lecture Plan

Lecture Number	Topics to be covered
1.	Introduction about the course, Mechanics of a particle
2.	Mechanics of a system of particles, centre of mass and work energy theorem
3.	Constraints and their classifications, principle of virtual work
4.	D'Alembert's principle, generalized coordinates, Lagrange's equation
5.	Problem solving using Lagrangian formalism
6.	Velocity dependent potentials and dissipative systems
7.	Configuration space, Hamilton's action principle, Calculus of variation and Euler-Lagrange's equation for one variable
8.	Calculus of variation and Euler-Lagrange's equation for more than one variable, Derivation of Lagrange's equation using action principle.
9.	Method of Lagrange's undetermined multipliers for nonholomomic systems
10.	First integrals of Lagrange's equation, generalized momenta, cyclic coordinates, conservation of linear momentum using cyclic coordinates
11.	Conservation of angular momentum using cyclic coordinate, Noether's theorem (only statement),
12.	Conservation of energy and Jacobi's integral.
13.	The two-body central force problem, reduction to equivalent one body problem, Equation of motion and first integrals: angular momentum and energy
14.	Equivalent one-dimensional problem and classification of orbits, differential equation for orbits
15.	Kepler's problem, Laplace Runge Lenze vector, virial theorem
16.	Scattering in a central force field, cross-section, impact parameter and Rutherford scattering.
17.	Rutherford scattering continued, transformation of scattering problem to laboratory coordinates
18.	Kinematics of rigid body motion, degrees of freedom, space and body set of axes, direction cosines
19.	Orthogonal transformations, active and passive transformations, Euler angles
20.	Euler theorem on the motion of a rigid body, Infinitesimal rotations
21.	Rate of change of a vector, Uniformly rotating frames and Coriolis force
22.	Angular momentum and Kinetic energy of a rigid body, momentum of inertia tensor, principle axes
23.	Euler equation of motion for a rigid body, force free motion of a rigid body.
24.	Small Oscillations, stable and unstable equilibrium, Lagrange's equations for coupled oscillators
25.	The eigen value equation and the principle axis transformation
26.	Frequency of vibrations and normal modes, Free vibrations of a linear tri-atomic molecule.

27.	Legendre transformations and Hamilton's equations of motion
28.	Interpretation of Hamiltonian, construction of Hamiltonian from Lagrangian, Examples of Hamiltonian formalism, Hamiltonian for a charged particle in electromagnetic field.
29.	Cyclic coordinates and conservation theorems, Routh's procedure
30.	Phase space, derivation of Hamilton's equations of motion from action principle
31.	Canonical transformations, generating functions
32.	Examples of canonical transformations, Solving harmonic oscillator problem using canonical transformation
33.	Poisson bracket, Equation of motion in form of Poisson bracket, Liouville's theorem
34.	Hamilton-Jacobi equation and solving harmonic oscillator using this.
35.	Minkowski spacetime and Lorentz transformations, timelik**e**, spacelike and lightlike intervals
36.	Light cone, Lorentz metric and line element, four-vector formalism, contravariant and covariant tensors, velocity four-vector. Addition of velocities using four-vector.
37.	Lagrangian for a particle in special relativity, equation of motion using action principle, energy, momentum and Hamiltonian. Energy-momentum conservation,
38.	Relativistic form of Newton's second law, force four vector and acceleration four vector. Collision of particles in special relativity.
39.	Electrodynamics in four-vector formalism, Relativistic potentials, current four-vector, Maxwell's stress tensor and Maxwell's equations in four-vector formalism,

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT505	**Quantum Mechanics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)
This course aims to provide the students basic concepts and formalism of quantum mechanics. Additional topics discussed will be angular momentum, symmetries and standard approximation techniques for static quantum systems.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Abstract formulation: Hilbert space, inner product space, eigen values and eigen functions, Dirac notation, operators, commutator and operator algebra, orthonormality, completeness, closure, position and momentum representation, generalized uncertainty principle, change of basis and unitary transformation, expectation values, Ehrenfest's theorem; Schrodinger equation (time-dependent and time independent), eigen value problems

(No. of lectures: 16)

Schrodinger picture, Heisenberg picture, Harmonic oscillator: operator method, two body problem, hydrogen atom; Symmetries, conservation laws, invariance under space and time translations and space rotation; angular momentum algebra, spin, addition of angular momenta, Clebsch-Gordan Coefficients

(No. of lectures: 13)

Time independent perturbation theory, normal Zeeman and Stark effects, WKB approximation and variational method

(No. of lectures: 10)

Recommended Readings

Text books –

1. Quantum Mechanics, Theory and Applications: A.K. Ghatak and S. Loknathan, (McMillan India)
2. Introduction to Quantum Mechanics: David J. Griffiths (Pearson Education)
3. Quantum Mechanics – A Modern Approach: Ashok Das and A.C. Milissiones, (Gordon and Breach Science Publishers)

Reference books –

1. Quantum Mechanics: R. Shankar.
2. Quantum Mechanics, B.H. Bransden, C.J. Joachain
3. Quantum Mechanics: E. Merzbacher, (Wiley).
4. Quantum Mechanics: L.I. Schiff, (McGraw Hill).
5. Quantum Mechanics: L. D. Landau and E. M. Liefshitz (Pergamon Press).
6. Quantum Mechanics- An Introduction: Walter Greiner (Springer).
7. Modern Quantum Mechanics: J.J. Sakurai, (Addision Wesley Publishing Co.).
8. Feynmann Lecturers: Vol I, II & III.
9. Quantum Mechanics, Stephen Gasiorowicz.

Lecture Plan

Lecture No.	Topics to be covered
1.	Hilbert space
2.	Inner product space, eigen values and eigen functions
3.	Dirac notation, operators
4.	Commutator and operator algebra
5.	Orthonormality, completeness, closure
6.	Position and momentum representation
7.	Generalized uncertainty principle
8.	Change of basis and unitary transformation
9.	Change of basis and unitary transformation
10.	Expectation values
11.	Ehrenfest's theorem
12.	Schrodinger equation (time-dependent and time independent)
13.	Eigen value problems
14.	Eigen value problems
15.	Eigen value problems
16.	Eigen value problems
17.	Schrodinger picture,
18.	Heisenberg picture, Dirac interaction picture
19.	Harmonic oscillator: operator method
20.	Harmonic oscillator: operator method
21.	Harmonic oscillator: operator method
22.	Two body problem, hydrogen atom;
23.	Two body problem, hydrogen atom;
24.	Symmetries, conservation laws
25.	Invariance under space and time translations and space rotation
26.	Angular momentum algebra, spin,
27.	Addition of angular momenta,
28.	Addition of angular momenta,
29.	Clebsch-Gordan Coefficients
30.	Time independent perturbation theory
31.	Time independent perturbation theory
32.	Time independent perturbation theory
33.	Normal Zeeman effect
34.	Normal Zeeman effect
35.	Stark effect
36.	Stark effect
37.	WKB approximation
38.	Variational method
39.	Variational method

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT504	Mathematical Methods in Physics	4	3	1	0	0

PREREQUISITE COURSES

None

COURSE OBJECTIVES

1. To impart mathematical concepts and techniques required for undergraduate studies in Physics.
2. To encourage the development of the ability to apply these ideas in heretofore unseen problems and situations, including other mathematical disciplines.

COURSE ASSESSMENT

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Vector spaces, matrices, eigenvalues and eigenvectors, Cayley-Hamilton theorem, Gram-Schmidt orthogonalization process, groups, finite groups, non-Abelian groups, permutation groups, subgroups, SU(3) and O(3) groups.

(No. of lectures: 12)

Motivation for tensors, coordinate transformations, metric, algebra of tensors, Cartesian tensors, improper rotations and pseudo tensors, quotient law, isotropic tensors, dual tensors, physical applications of tensors, non-Cartesian coordinates

(No. of lectures: 8)

Laplace and Fourier transforms, their properties, inverse Laplace and Fourier transforms, application of Laplace and Fourier transforms in solving linear differential equations, Sturm-Liouville equation, Green's function and its applications.

(No. of lectures: 12)

Elements of complex analysis, analytic functions, Taylor and Laurent series, poles, residues and evaluation of integrals, applications towards Green's functions

(No. of lectures: 7)

Text Books:

1. Mathematics for Physics, Michael Stone and Paul Goldbart (Cambridge University Press)
2. A Guided Tour of Mathematical Physics (Third Edition), Roel Snieder and Kasper van Wijk (Cambridge University Press)
3. A Course in Mathematics for Students of Physics Vol. 1, Paul Bamberg and Shlomo Sternberg (Cambridge University Press)
4. Elements of Group Theory for Physicists, A. W. Joshi (Wiley Eastern Ltd.)

Reference Books:

1. Mathematical Methods for Physicists, G. Arfken, H. Weber and F. Harris (Academic Press)
2. Elements of Group Theory for Physicists, A. W. Joshi (Wiley Eastern Ltd.)
3. Mathematical Methods of Physics, Mathews and Walker (Pearson Educations)
4. Mathematical Physics, I. C. Goyal (Laxmi Publications Private Limited)

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction
2.	Vectors and vector spaces
3.	Matrices, eigenvalues and eigenvectors
4.	Gram-Schmidt orthogonalization
5.	Cayley-Hamilton Theorem
6.	Introduction to group theory, Abelian and non-Abelian groups
7.	Multiplication table, permutation groups
8.	Introduction to Lie groups
9.	Generators and symmetries
10.	SO(2) group
11.	SO(3) group
12.	SU(2) group
13.	Introduction to tensors
14.	Rotations
15.	Improper rotations and pseudo tensors
16.	Metric tensor
17.	General coordinate transformations
18.	Non-cartesian coordinates I
19.	Non-cartesian coordinates II
20.	Problems based on Module II
21.	Introduction to integral transforms
22.	Fourier transform I
23.	Fourier transform II
24.	Using Fourier transforms to solve differential equations
25.	Laplace transform I
26.	Laplace transform II
27.	Using Laplace transforms to solve differential equations
28.	Sturm-Liouville theory I
29.	Sturm-Liouville theory II
30.	Green’s functions
31.	Constructing Green’s functions
32.	Using Green’s functions to solve differential equations
33.	Introduction to Complex analysis, Cauchy-Reimann conditions
34.	Cauchy’s integral theorem
35.	Laurent series, properties and convergence
36.	Residue Theorem
37.	Computing integrals using complex analysis I
38.	Computing integrals using complex analysis II
39.	Applications to Green’s functions

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT502	**Electronics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE – None

COURSE OBJECTIVE(s)

COURSE OBJECTIVE(s)

This course gives an overview of fundamentals of operational amplifier and digital circuits. After competition of this course, students should be able to design analog and digital circuits for required applications. They will learn how to analyse a circuit diagram and the limitations of those circuits.

CO1	Understand the basics of operational amplifier & digital circuits.
CO2	Design and analyse analog & digital circuits for given specifications.
CO3	Compare design issues, advantages, disadvantages and limitations of analog & digital circuits.
CO4	Implementation of knowledge for analog and digital circuits in various application.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based on assignments, quizzes, and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Review of Diodes and Transistors, Basic of op-amps, Op-amps circuit analysis, applications of op-amps- summer, subtractor, integrator, and differentiator, amplifier designing, Comparators, The Schmitt Trigger, summer, subtractor, integrator, and differentiator, Transfer function and Bode plots, Frequency and time response of filters, Active filters. Passive filters, Sallen-key topology, Higher order filters, Op-amp oscillators-Wien bridge and phase-shift oscillators, 555 timers: monostable and **astable** multivibrator, Regulated power supply, Analog Computers using op-amps.

(No. of lectures: 20)

Digital electronics- Boolean algebra, De Morgan's theorems, Simplification of Logic Circuit using Boolean Algebra. Number systems and codes, Error detection, Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) POS, Karnaugh Map.

(No. of lectures: 09)

Flip-flops, Registers, Counters, D/A conversion and A/D conversion. Concepts of Microprocessor, Microprocessor based system design

(No. of lectures: 10)

.

Recommended Readings

Text books

1. Electronic Principles: Malvino and Bates (McGraw Hill Education).
2. The Art of Electronics: Horowitz and Hill (Cambridge University Press)
3. Digital Principles and Applications: A. P. Malvino and Donald P. Leach (TMH)
4. Fundamental of Digital Circuits: P Anand Kumar (PHI)
5. Electronic Devices and Circuit Theory: Robert Boylestad and Louis Nashdsky (PHI)
6. Microprocessor Architecture, Programming, and Applications with the 8085: R Gaonkar (Penram International Publishing)

Reference books-

1. Op-Amps and Linear Integrated Circuits: Ramakanth A. Gayakwad (PHI)
2. Digital Fundamentals: Floyd & Jain (Pearson Education)
3. Digital Electronics: Morris Nano (Pearson)

Lecture Plan

Lectures no.	Topics to be covered
1.	Review of Diodes
2.	Review of Transistors
3.	Basic of op-amps, Open-loop and closed-loop gain, Slew rate, Bias and offset
4.	Golden rules, Inverting and non-inverting op-amps, Op-amp buffer and loading effects
5.	Op-amp applications: summer, subtractor, integrator, and differentiator
6.	Designing of amplifiers and Impedance Problem
7.	Comparators, The Schmitt Trigger
8.	Rectifier, peak-detector, clipper and clamper using op-amps
9.	Transfer function and Bode plots
10.	Frequency and time response of filters, Active Filters
11.	Passive filters
12.	Second order filters
13.	Sallen-key topology
14.	Higher order filters
15.	Op-amp oscillators
16.	Wien bridge and phase-shift oscillators
17.	555 timers: monostable, and astable multivibrator
18.	Bistable multivibrator
19.	Regulated power supply
20.	Analog Computer
21.	Boolean algebra, De Morgan’s theorems
22.	Universal Logic Gates and simplification of Logic Circuit
23.	Number systems
24.	Codes
25.	Error detection
26.	Minterms and Maxterms
27.	Conversion of a Truth Table into an Equivalent Logic Circuit by SOP/POS
28.	Karnaugh Map (cont.)
29.	Karnaugh Map
30.	Flip Flop and its type
31.	RS, D and JK flip flop
32.	Shift registers (cont.)
33.	Shift registers (cont.)
34.	Counters (cont.)
35.	Counters (cont.)
36.	A/D conversion
37.	D/A converter
38.	History and concepts of Microprocessor
39.	Microprocessor based system design

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT507	**Electrodynamics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE
None

COURSE OBJECTIVE(s)

This course gives an overview of fundamentals of electrodynamics. After completion of this course, students should be able to use various techniques commonly used in electrodynamics to find the electric/magnetic fields and potentials of different systems. Students will understand Maxwell's equation, the basic properties of wave propagation, diffraction, interference and electromagnetic radiation.

COURSE OUTCOMES:

CO1	Understand the basics of electrostatics and magnetostatics.
CO2	Formulate and solve electromagnetic problems.
CO3	Implementation of fundamental knowledge for electrodynamics in various fields.
CO4	Understand the interdisciplinary nature of concepts of electrodynamics.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Gauss’s Divergence Theorem, Stokes’ Theorem, Basics of Electrostatics, Poisson’s and Laplace’s equations, Uniqueness theorems, Electrostatic boundary value problems with Green’s function, Method of images, Techniques for calculating potentials, Multipole expansion, Polarization.

(No. of lectures: 12)

Divergence and Curl of magnetic field, Boundary conditions, Magnetic vector potentials, Magnetic field inside matter, Equation of continuity, Maxwell’s displacement current, Maxwell’s equations, Maxwell’s equations inside the matter for time varying fields, Poynting vector, Maxwell's stress tensor.

(No. of lectures: 07)

Electromagnetic wave equation, Electromagnetic waves in vacuum, Electromagnetic waves in matter, Reflection and Transmission at normal and oblique incidence, Electromagnetic waves in conductors, Frequency dependence of permittivity, Introduction to waveguides.

(No. of lectures: 07)

Scalar and vector potentials, Potential formulation of Maxwell’s equations, Gauge transformations, Coulomb and Lorentz gauges, Retarded potentials, Lienard-Wiechert potentials, Field of a uniformly moving point charge, Dipole radiation, Electric dipole radiation, Magnetic dipole radiation, Radiation from an arbitrary source, Power radiated by a point charge.

(No. of lectures: 13)

Text Books:

1. Introduction to Electrodynamics: David J. Griffiths, (Prentice Hall of India).
2. Classical Electrodynamics: J.D. Jackson, (John Wiley and Sons).
3. Elements of Electrodynamics: Matthew N. O. Sadiku (Oxford University Press)
4. Modern Electrodynamics: Andrew Zangwill (Cambridge University Press)

Reference Books:

1. Foundations of Electromagnetic Theory: J. Reitz and F.J. Milford (Addison-Wesley).
2. Classical Electricity and Magnetism: W.K.H. Panofsky, M. Phillips (Addison Wesley).
3. Fields and Waves Electromagnetics: David K. Cheng (Addison – Wesley).
4. Electromagnetic Waves and Radiating Systems: E.C. Jordan (Prentice Hall of India).
5. The Classical Theory of Fields: L.D. Landau, E.M. Lifshitz (Pergamon Press, Oxford).

Lecture Plan

Lecture No.	Topics to be covered
1	Gauss's Divergence Theorem, Stokes' Theorem
2-3	Basics of Electrostatics
4	Laplace and Poisson's equations, Uniqueness of solutions with Dirichlet and Neumann boundary conditions.
5	Electrostatic boundary value problem with Green's function
6	Method of images
7	Separation of variables approach in Cartesian coordinate system
8	Separation of variables approach in Spherical coordinate system
9	Solution of potential problems in Spherical coordinate systems with Green's function
10	Multipole expansion
11-12	Polarization and field of polarized object
13	Divergence and Curl of magnetic field, Boundary conditions
14	Magnetic Vector Potential
15	Magnetic field inside matter
16	Equation of continuity, Maxwell's correction to Ampere's law
17	Maxwell's Equation and Maxwell's equation inside the matter
18	Poynting Vector
19	Maxwell's Stress Tensor
20	Electromagnetic wave equation, Electromagnetic waves in vacuum
21	EM waves in matter, Reflection and transmission at normal incidence
22-23	Reflection and transmission at oblique incidence
24	EM waves in conductors
25	Frequency dependence of permittivity
26	Introduction to waveguides
27	Scalar and vector potentials
28	Potential formulation of Maxwell's equations
29	Gauge transformations: Coulomb and Lorentz Gauges
30	Retarded Potentials
31	Lienard-Wiechert potentials
32	Fields of a moving point charge
33-34	Electric dipole radiation
35	Magnetic dipole radiation
36-37	Radiation from an arbitrary source
38-39	Power radiated by a point charge

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT505	Atomic & Molecular Physics	4	3	1	0	0

PREREQUISITE - None

COURSE OBJECTIVE(s)
This course aims to provide the students basic concepts and atomic physics and molecular spectroscopy. Students would come to know about the hydrogen and helium spectra, spin-orbit interaction, coupling schemes, spectra under electric and magnetic field. factors influencing spectral line width. The other topics contain valence band theory, Born-Oppenheimer approximation, rotational, vibrational and electronic spectra of diatomic molecules, Frank-Condon principle, Raman effect etc.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Atomic Physics (one electron): Hydrogen atom spectrum, spin-orbit interaction and relativistic shift, fine structure, Lamb shift (only qualitative treatment), nuclear magnetic dipole interaction and hyper fine structure, electron spin and orbital magnetic dipole moment of electron, Larmor precession

(No. of lectures: 9)

Atomic Physics (many electron atoms): Helium spectrum, Vector atom model, Equivalent and non-equivalent electrons, Angular momentum coupling schemes: LS & JJ Coupling, Interaction with external fields: Stark effect, Zeeman and Paschen-Back effect, General factors influencing spectral line width and intensities

(No. of lectures: 12)

Molecular Physics: System with identical particles: exchange symmetry, Pauli exclusion principle, variation method, hydrogen molecular ion, valence band theory, hydrogen molecule.

(No. of lectures: 6)

Molecular Spectroscopy: Born-Oppenheimer approximation; rotational, vibrational and electronic spectra of diatomic molecules, Frank-Condon principle, Raman effect, advanced topics in atomic and molecular physics

(No. of lectures: 12)

Recommended Readings

Text books –

1. Atomic Physics: Christopher J. Foot (Oxford University Press)
2. Physics of atoms and molecules, B. H. Bransden and C. J. Joachain, Pearson
3. Fundamentals of Molecular Spectroscopy: C. N. Banwell and E. M. McCash (McGraw)
4. Atomic and Molecular Spectra: Lasers by Raj Kumar (KNRN)

Reference books –

1. Introduction to Atomic Spectra: H. E. White (McGraw Hill).
2. Molecular Spectroscopy: K. V. Raman, R. Gopalan and P.S. Raghavan (Thomson).
3. Spectra of Atoms and Molecules: Peter F. Bernath (Oxford University Press)

Lecture Plan

Lecture No.	Topics to be covered
1	Basic introduction of emission and absorption spectrum, Bohr atom
2	Hydrogen atom spectrum, Introduction of Schrodinger equation for hydrogen atom
3	Schrodinger equation for hydrogen atom
4	Spin-Orbit interaction
5	Relativistic shift, Hydrogen fine-structure
6	Lamb shift (only qualitative treatment)
7	Magnetic dipole interaction and hyper fine structure
8	Electron spin and Orbital magnetic dipole moment of electron
9	Larmor precession
10	Spectra of helium
11	Spectra of helium
12	Vector atom model, Equivalent and non-equivalent electrons
13	Central Field approximation (basic introduction), Introduction of angular momentum coupling schemes
14-15	LS & JJ Coupling
16	Normal Zeman effect
17-18	Anomalous Zeeman effect
19	Paschen-Back effect
20	Stark effect
21	General factors influencing spectral line width and intensities
22	System with identical particles
23	Exchange symmetry, Pauli exclusion principle
24	Variation method
24	Hydrogen Molecular Ion
26-27	Hydrogen molecule (Heitler-London method)
28	Born-Oppenheimer approximation
29	Introduction to rotational, and electronic spectra of diatomic molecules
30	Rotational spectra
31	Rotational spectra
32	Vibrational spectra
33	Vibrational-Rotational spectra
34	Electronic spectra
35	Frank-Condon principle
36	Raman effect (classical)
37	Raman effect (quantum)
38-39	Advanced topics in atomic and molecular physics

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT672	Statistical Mechanics	4	3	1	0	0

PREREQUISITE – Quantum Mechanics, Thermodynamics

COURSE OBJECTIVE(s)

After successfully completing this course student should be able to understand basic physics principles underlying thermodynamic principles. They will also be able to use this knowledge in other branches of physics, such as condensed matter, astrophysics, magnetism etc.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Review of thermodynamics. Introduction to statistical methods: micro and macro states, phase space, Liouville's theorem, postulates of statistical mechanics, system in thermodynamic equilibrium, law of equipartition of energy and its applications

(No. of lectures: 8)

Statistical ensembles: micro canonical ensembles, statistical interpretation of entropy, Gibbs paradox, Canonical and ensembles, partition functions and its properties (factorizability), calculation of thermodynamic quantities, Fluctuations in energy and other thermodynamic quantities in canonical ensemble

(No. of lectures: 14)

Grand Canonical ensemble, Calculation of thermodynamic quantities using grand canonical ensemble approach, fluctuations in energy & other thermodynamic quantities.

(No. of lectures: 5)

Quantum distribution functions: Bose-Einstein (BE) and Fermi-Dirac (FD) statistics, vis–a–vis classical M-B statistics, Applications of FD and BE statistics: such as paramagnetism, liquid Helium problem etc.; Boltzmann Transport Equation and its applications, Phase transitions and its classifications: order parameter critical exponents and some important phase transitions.

(No. of lectures: 11)

TEXT/ REFERENCE BOOKS:-

1. Statistical Mechanics: R. K. Patharia & Paul D. Beale (Elsevier, Academic Press)
2. Statistical Mechanics, An Introduction: Evelyn Guha (Narosa Publishing House)
3. Statistical Mechanics: K. Huang (John Wiley and Sons).
4. Fundamentals of Statistical and Thermal Physics: Reif (McGraw Hill).
5. An Introductory course on Statistical Mechanics: P.B. Pal (Narosa)

Lecture Plan

Lecture No.	Topics to be covered
1.	Review of thermodynamics.
2.	Introduction to statistical methods: micro and macro states,
3.	phase space, Liouville's theorem,
4.	postulates of statistical mechanics,
5.	system in thermodynamic equilibrium,
6.	law of equipartition of energy and its applications
7.	Recap
8.	Recap
9.	Statistical ensembles: micro canonical ensembles,
10.	statistical interpretation of entropy,
11.	Gibbs paradox
12.	Sackur-Tetrode Equation
13.	Canonical and ensembles,
14.	partition functions
15.	properties (factorizability),
16.	calculation of thermodynamic quantities,
17.	Internal Energy
18.	Helmoltz Free Energy
19.	Gibbs Entropy Formula
20.	Fluctuations in energy and other thermodynamic quantities in canonical ensemble
21.	Recap
22.	Recap
23.	Grand Canonical ensemble,
24.	Contd.
25.	Calculation of thermodynamic quantities using grand canonical ensemble approach,
26.	fluctuations in energy & other thermodynamic quantities.
27.	Recap
28.	Quantum distribution functions: Bose-Einstein (BE) and Fermi-Dirac (FD) statistics, vis–a–vis classical M-B statistics,
29.	Contd.
30.	Contd.
31.	Applications of FD and BE statistics:
32.	paramagnetism
33.	liquid Helium problem
34.	Boltzmann Transport Equation and its applications,
35.	Contd.
36.	Contd.
37.	Phase transitions and its classifications: Gibbs Phase Rule
38.	order parameter critical exponents and some important phase transitions.
39.	Review of the course, resolving queries, and conclusion

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT508	**Nuclear and Particle Physics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)

This course aims to provide the students with basic concepts and formalism of Nuclear and Particle Physics. Additional topics discussed will be Nuclear Models, Detectors, and Particle Physics.

COURSE ASSESSMENT

The Course Assessment (culminating in the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Nuclear binding energy, electric and magnetic moments, nuclear force: deuteron, n-p and p-p scattering, semi-empirical mass formula: liquid drop model, nuclear shell model, shell model predictions, selection rules, nuclear isomerism, and collective nuclear model, Nuclear decay theories for α, β and γ decay, transition probabilities, selection rules, general characteristics of weak interaction, nuclear reactions, partial wave analysis, compound nucleus formation, resonance scattering and reaction, optical model, reactor physics: fission reactors, four-factor formula, schemes for nuclear fusion.

(No. of lectures: 18)

Gas-filled counters, scintillator counters, solid-state detectors, surface barrier detectors, proton synchrotrons, linear accelerations, and acceleration of heavy ions.

(No. of lectures: 6)

Elementary particles and their interactions, hadrons and leptons, symmetry and conservation laws, elementary ideas of CP and CPT invariance, relativistic kinematics, classification of hadrons, Lie algebra - SU (2) - SU (3) multiplets, quark model, Gell-mann Okubo mass formula for octet and decuplet hadrons, parity non-conservation in weak interaction.

(No. of lectures: 15)

Recommended Readings

Text books –

1. Introductory Nuclear Physics: Kennath S Keane (Wiley).
2. Techniques for Nuclear and Particle Physics Experiments: W.R. Leo (Springer, 1994).
3. Radiation Detection and Measurement: G. F. Knoll (John Wiley, 1989).
4. Introduction to Elementary Particle Physics: David Griffith (Wiley).
5. Introduction to High Energy Physics: Donald H. Perkins (Cambridge University Press).
6. Nuclear Physics: DC Tayal (Himalaya Publishing House)
7. Concepts of Modern Physics: Aurthur Beiser (Mc GrawHill)
8. Quark and Leptons: An Introductory Course in Modern Particle Physics: Francis Halzen,Alan D. Martin (John Wiley and Sons).

Reference books –

1. Structure of Nucleus: M.A. Preston and R.K. Bhaduri (Addison Wesley).
2. Nuclear Physics: R.R. Roy and B.P. Nigam (Wiley Eastern).
3. Introduction to Nuclear Physics: H. Enge (Addison Wesley).
4. The Atomic Nucleus: R.D. Evans (McGraw Hill).
5. Nuclear Physics: Kaplan (Addison Wesley).
6. Introductory Nuclear Physics: S. Wong (Prentice Hall of India).
7. Concepts of Nuclear Physics: Cohen (Tata McGraw Hill).
8. Nuclear Reactor Engineering: Glasstone and Sesonske (Van Nostrand Reinhold Co.)
9. Introduction to Experimental Nuclear Physics: R.M. Singru (Wiley Eastern)

Lecture Plan

Lecture No.	Topics to be covered
1.	Nuclear binding energy
2.	electric and magnetic moments
3	nuclear force: deuteron, n-p and p-p scattering
4.	semi-empirical mass formula: liquid drop model
5.	nuclear shell model
6.	shell model predictions, selection rules
7.	nuclear isomerism
8.	collective nuclear model
9.	Nuclear decay theories for α, β and γ decay
10.	transition probabilities, selection rules
11	general characteristics of weak interaction
12	nuclear reactions
13	partial wave analysis
14	compound nucleus formation
15	resonance scattering and reaction
16	optical model
17	reactor physics: fission reactors
18.	four-factor formula, schemes for nuclear fusion
19.	Gas-filled counters
20.	scintillator counters
21.	solid-state detectors
22.	surface barrier detectors
23.	proton synchrotrons
24.	linear accelerations, and acceleration of heavy ions
25.	Elementary particles and their interactions
26.	hadrons and leptons
27.	symmetry and conservation laws
28.	elementary ideas of CP and CPT invariance
29.	relativistic kinematics
30.	relativistic kinematics
31.	classification of hadrons
32.	Lie algebra - SU (2) - SU (3) multiplets
33.	Lie algebra - SU (2) - SU (3) multiplets
34.	quark model
35.	quark model
36.	Gell-mann Okubo mass formula for octet hadrons
37.	Gell-mann Okubo mass formula for decuplet hadrons
38.	parity non-conservation in weak interaction
39.	parity non-conservation in weak interaction

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT602	**Solid State Physics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)
This course aims to provide the students basic concepts and formalism of Solid-State Physics. Additional topics discussed will be structural, electrical, and magnetic behavior of different types of solids.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Review of basic crystal structures and bondings in solids, symmetries in solids, point groups and space groups, X-ray diffraction and reciprocal lattice, electron and neutron diffraction, lattice vibrations: dispersion relations and their interpretation for one dimensional mono and diatomic lattice types, concept of phonons Einstein and Debye models.

(No. of lectures: 12)

Free electron theory, Bloch theorem, energy bands in solids: Kronig-Penney model, nearly free electron (NFE) model, tight binding approximation, concept of Fermi level and Fermi surfaces, Semiconductor Junctions: homo and heterojunctions. Examples of band structures of common materials

(No. of lectures: 10)

Dielectric properties and losses, Thermal conductivity and thermal expansion, concept of thermoelectrics, phase transformations: classification.

(No. of lectures: 8)

Classical and quantum Hall effect, Superconductivity: BCS theory and Josephson effect, classical theory of magnetism, quantum theory of magnetism: para- and ferromagnetism, antiferro- and ferrimagnetic materials, Heisenberg model.

(No. of lectures: 9)

Recommended Readings

Text books –

1. Introduction to Solid State Physics: C. Kittel, 7th Ed. (John Wiley and Sons).
2. Solid State Physics: N. Ashcroft and N.D. Mermin (Holt, Rinehart and Winston).
3. Solid State Physics: A.J. Dekker (Prentice Hall of India, New Delhi).
4. Magnetism in Condensed Matter: Stephen Blundel (Oxford Master Series in Condensed Matter Physics).

Reference books –

1. Solid State Physics: Azaroff (McGraw Hill).
2. Solid State Physics: M.S. Rogalski and S.B. Palmer (Gordon & Breach Science Pub.).
3. Introductory Solid-State Physics: H.P. Myers (Viva books Pvt. Ltd.).
4. Solid State Physics: Wahab (Narosa).
5. Solid State Physics: Gerald Burns (Academic Press).
6. Introduction to Nanotechnology: Poole Jr. and Owens (J. Wiley and Sons).

<u>Lecture Plan</u>

Lecture No.	Topics to be covered
1.	Introduction and background
2.	Review of basic crystal structures
3.	bondings in solids
4.	symmetries in solids
5.	point groups and space groups,
6.	X-ray diffraction and reciprocal lattice
7.	X-ray diffraction and reciprocal lattice
8.	electron and neutron diffraction,
9.	lattice vibrations: dispersion relations
10.	one dimensional mono and diatomic lattice types
11.	concept of phonons
12.	Einstein and Debye models.
13.	Free electron theory
14.	Bloch theorem
15.	energy bands in solids
16.	Kronig-Penney model
17.	nearly free electron (NFE) model
18.	tight binding approximation
19.	concept of Fermi level and Fermi surfaces
20.	Semiconductor Junctions
21.	homo and heterojunctions
22.	Examples of band structures of common materials
23.	Dielectric properties and losses
24.	Dielectric properties and losses
25.	Thermal conductivity
26.	thermal expansion
27.	concept of thermoelectrics
28.	concept of thermoelectrics
29.	phase transformations: classification.
30.	phase transformations: classification.
31.	Classical and quantum Hall effect
32.	Classical and quantum Hall effect
33.	Superconductivity
34.	BCS theory
35.	Josephson effect
36.	quantum theory of magnetism
37.	para- and ferromagnetism, antiferro- and ferrimagnetic materials
38.	Heisenberg molecular field theory
39.	Review of classwork and concepts

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHP503	**Electronics Lab**	**4**	**0**	**0**	**8**	**0**

COURSE CONTENTS

1. To determine the Offset voltage, Offset current, and Bias Current of an op-amp
2. To study the application of op-amps as Inverting Amplifier, Non-inverting Amplifier, and Summing Amplifier
3. To study the application of op-amps as Integrator and Differentiator
4. To study the characteristics of Filters: Low pass, High Pass, and Band Pass
5. To study Astable, and Monostable Multivibrator
6. To study the application of op-amps as Comparator, Function Generation, and The Triangle-Square generator
7. To study the Wien Bridge Oscillator
8. To design Active Half-Wave and Full-wave Rectifier
9. To design and study Unregulated and Regulated Power supply
10. To study the behavior of Basic flip-flops
11. To study Counter and Shift register
12. To study D/A and A/D convertor
13. To perform 8 Bit Addition, Subtraction, Multiplication and Division by using MICROPROCESSORS (8086 Assembly Language Programming)

TEXT BOOKS

1. Electronics Principles, A. P. Malvino (McGraw-Hill Education)
2. The art of electronics, P. Horowitz and W. Hill (Cambridge University Press)
3. Digital Electronics, S. Ghoshal (Cengage India Private Limited)
4. Op-Amps and Linear Integrated Circuits, R. A. Gayakwad (PHI)

REFERENCE BOOKS

1. Fundamentals of Digital Circuits, A. Anand Kumar (Prentice-Hall of India Pvt. Ltd)
2. Electronic Devices and Circuit Theory, Robert Boylestad and Louis Nashdsky (PHI)
3. Digital Fundamentals, Floyd & Jain (Pearson Education)
4. Operational Amplifiers & Linear Integrated Circuits: Theory and Application Laboratory Manual/3E, James M. Fiore (Dissidents)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHP509	General Physics Lab	4	0	0	8	0

COURSE CONTENTS

1. To calibrate and determine the resolution of the Gamma ray spectrometer.
2. Experimental studies of gamma ray spectrometer.
   (a) To calibrate the energy of the spectrometer.
   (b) To identify the unknown source.
3. (a) To study the characteristics of the GM tube and determine its operating voltage, plateau length and slope with determination of efficiency for beta and gamma radiation.
   (b) To determine the linear and mass attenuation coefficients using gamma source using GM counter.
4. To study the electron spin resonance and to determine the Lande's g- factor.
5. To study normal Zeeman effect in transverse and longitudinal configurations.
6. To study the optical properties of polymer thin films grafted by fluorescence dye.
7. To measure the emission spectra of Hydrogen atom.
8. Lifetime of a short-lived radioactive source.
9. Compton Scattering Experiment to measure the scattering angle of scattered photons.
10. Resolving Time of G. M. Counter set-up.

TEXT BOOKS

1. Introduction to experimental nuclear physics, R. M. Singru (Wiley Eastern Pvt.Ltd.)
2. Introductory Nuclear Physics: K. S. Keane (Wiley).
3. Fundamentals of Molecular Spectroscopy: C. N. Banwell and E. M. McCash (McGraw)

REFERENCE BOOKS

1. Techniques for Nuclear and Particle Physics Experiments: W. R. Leo (Springer, 1994).
2. Molecular Spectroscopy: K. V. Raman, R. Gopalan and P.S. Raghavan (Thomson).

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

<u>Programme: M.Sc. Physics</u>

DETAILS OF THE COURSE

Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHP603	**Advanced Physics Lab**	**4**	**0**	**0**	**8**	**0**

COURSE CONTENTS

1. (a) To plot the I-V characteristics of a solar cell and measure the short circuit current, open circuit voltage and maximum power point.

   (b) To calculate the energy conversion efficiency of a solar cell.
2. (a) To measure the Hall coefficient of a given material.

   (b) To study the temperature dependence of Hall coefficient of a given material.
3. To study the Gaussian nature of laser beams and carry out the diffraction experiments.
4. To study the speed of ultrasonic velocity in liquids and measure elasticity parameters.
5. To record a Frank Hertz curve for Mercury and measure the energy emission of free electrons in a gas filled triode.
6. To measure the magnetic susceptibility of paramagnetic solution by Quincke's method and to find the ionic molecular susceptibility and magnetic moment.
7. To determine the Curie temperature of a given solid and study the magnetic transition.
8. To study Bragg's law by microwave diffraction.
9. To study the Faraday Effect and calculate the Verdet's constant.
10. To study the performance of different rechargeable batteries by using Battery tester.
11. To measure the band gap of a semiconductor material using four-probe method

TEXT BOOKS

1. Introduction to Solid State Physics: C. Kittel, 7th Ed. (John Wiley and Sons)
2. Solid State Physics: N. Ashcroft and N.D. Mermin (Holt, Rinehart and Winston).
3. Solid State Physics: A.J. Dekker (Prentice Hall of India, New Delhi).
4. Magnetism in Condensed Matter: Stephen Blundel (Oxford Master Series in Condensed Matter Physics).

5. Program Elective Courses

S. No.	Course code	Course Title	Course Coordinator
1.	21PHT817	Semiconductor Physics and Devices	Prof. Kanupriya Sachdev
2.	21PHT802	Advanced Techniques for Materials Characterization	Dr. Manoj Kumar
3.	24PHT801	Spintronics for Quantum Technology	Dr. Manoj Kumar
4.	21PHT819	Solar Energy and Applications	Dr. Debasish Sarkar
5.	24PHT802	Energy Materials and Devices	Dr. Debasish Sarkar
6.	24PHT803	Basics of Astronomy & Astrophysics	Dr. Subhayan Mandal
7.	21PHT816	Plasma Physics	Dr. Subhayan Mandal
8.	21PHT 806	General Theory of Relativity	Dr. Akhilesh Nautiyal
9.	24PHT804	Introduction to Monte Carlo Simulation	Dr. Kavita Lalwani
10.	24PHT805	Machine Learning in Physics	Dr. Kavita Lalwani
11.	21PHT809	Introduction To Quantum Field Theory	Dr. Anees Ahmed
12.	21PHT812	Nanostructured Materials and Applications	Dr. Srinivasa Rao Nelamarri
13.	24PHT806	Soft Materials	Dr. Kamlendra Awasthi
14.	21PHT813	Nanotechnology for Energy Applications	Dr. Kamlendra Awasthi
15.	24PHT807	Basic LabVIEW Programming	Dr. Anirban Dutta
16.	24PHT808	Membrane Technology for Energy Applications	Dr. Kamakshi Pandey
17.	21PHT801	Advanced Quantum Mechanics	Dr. K Venkataratnam Kamma
18.	21PHT814	Numerical Methods and Computer Programming	Dr. Rahul Singhal
19.	21PHT716	Materials Science and Engineering	Dr. Rahul Singhal
20.	21PHT821	Surface Physics	Dr. Rajnish Dhiman

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT817	**Semiconductor Physics and Devices**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – None

COURSE OBJECTIVE(s)
This course aims to equip the students with fundamental knowledge of semiconductor physics and explain the working and design of p-n junctions and semiconductor devices viz. BJTs and FETs. Preliminary knowledge of IC fabrication is also given.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Bipolar junction transistors, transistor as an amplifier and switch, junction field effect transistors, MOS capacitor, MOSFET devices, metal-semiconductors FET, hetero junctions- quantum wells,
(No. of lectures: 15)

Photonic devices-, Current and voltage in an illuminated junction solar cells, photo detectors, LEDs, semiconductor lasers, Hetero junction laser; techniques to measure properties of semiconductors- Resistivity measurement of a semiconductor, four probe method, Correction factors, arbitrary samples, Van der pauw technique, hall effect, spreading resistance for diffusion measurements

(No. of lectures: 14)

An overview of IC fabrication technology- Introduction, epitaxial growth, diffusion, oxidation, wafer doping and etching, photolithographic processing, ion implantation, clean room design, Wafer packaging

(No. of lectures: 10)

Recommended Readings

Text books-

1. Solid State Electronic Devices: B. G. Streetman and Banerjee (Prentice Hall of India)
2. Physics of Semiconductor Devices: S.M. Sze (John Wiley and Sons)

Reference books-

1. Principles of Electronic Materials: S.O. Kasap (McGraw Hill)
2. Principles of Semiconductor Devices: Sima Dimitrijev (Oxford University Press)
3. Physics of Semiconductor Devices: M. Schur (Prentice Hall of India)
4. Electrical Characterization of Semiconductor Materials and Devices, (Chapter 20) Springer Handbook of Electronic and Photonic Materials, ISBN 978-0-387- 26059-4, Springer-Verlag US
5. Semiconductor Physics and Devices: D A Neamen TMH III ed.

Online/E- resources

Nptel Video - Electronic Materials, Devices & Fabrication, IIT Madras, Mod 1, Lec 20-31

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction to semiconductors and PN junction theory
2.	Bipolar junction transistors,
3.	Bipolar junction transistors,
4.	Bipolar junction transistors,
5.	Bipolar junction transistors,
6.	Junction field effect transistors
7.	Junction field effect transistors
8.	MESFET device
9.	MOS capacitor
10.	MOS capacitor
11.	MOS capacitor
12.	MOSFET
13.	MOSFET
14.	Hetero junctions- quantum wells
15.	Hetero junctions- quantum wells
16.	Current and voltage in an illuminated junction
17.	Solar cells
18.	Solar cells
19.	Photo detectors
20.	LEDs
21.	Semiconductor lasers
22.	Hetero junction laser
23.	Resistivity measurement of a semiconductor
24.	Four probe method
25.	Correction factors, arbitrary samples
26.	Van der pauw technique
27.	Hall effect
28.	Spreading resistance for diffusion measurements
29.	Spreading resistance for diffusion measurements
30.	IC fabrication introduction
31.	Epitaxial growth
32.	Epitaxial growth
33.	Diffusion
34.	Oxidation
35.	Wafer doping and etching
36.	Photolithographic processing
37.	Ion implantation
38.	Clean room design
39.	Wafer packaging

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT802	**Advanced Techniques for Materials Characterization**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)
Impart fundamentals knowledge to masters' students in the field of Materials characterization using different techniques. Describe (phenomenologically) the principal phenomena behind different characterization techniques. Developing capability to use fundamental knowledge in application, and to solve problems independently based on these concepts.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Introduction to surfaces, interfaces and bulk of solid materials, classification, distinction and overview of surface and bulk characterization techniques. Techniques for atomic structure and surface morphology determination: working principle and data analysis for X-ray Diffraction (XRD), high-resolution transmission electron microscopy (HRTEM), low energy electron diffraction and microscope (LEED and LEEM), scanning tunneling microscopy (STM) and atomic force microscopy (AFM).

(No. of lectures: 16)

Techniques for compositional analysis: working principle and data analysis for the techniques- electron probe micro analysis (EPMA) and energy dispersive analysis (EDAX), X-ray fluorescence (XRF) and X-ray photoelectron spectroscopy (XPS).

(No. of lectures: 10)

Thermal analysis and other techniques: working principle and data analysis for the techniques- differential scanning calorimetry (DSC), differential thermal analysis (DTA) and thermo-gravimetric analysis (TGA).

(No. of lectures: 7)

Mini Project: Processing and analysis of selected characterization techniques data using Softwares.

(No. of lectures: 6)

Recommended Readings

Text books –

1. Surface Analysis Methods in Materials Science: D. J. O. Conner (Springer Verlag).
2. Surface and Interfaces of Solids: H. Lueth (Springer).
3. Advanced Techniques for Materials Characterization: A. K. Tyagi, M. Roy, S. K. Kulshrestha, S. Banerjee (Materials Science Foundations-Trans Tech Publications).

Reference books –

1. Vacuum Science and Technology: V. V. Rao, T. B. Ghosh, K. L. Chopra (Allied Publishers).
2. Instrumental Methods of Chemical Analyses: G.W. Ewing (McGraw Hill).
3. Characterization of Solid Surface: P.F. Kane (Plenum).

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction to the course syllabus
2.	Introduction to Materials characterization
3.	Introduction to surfaces, interfaces and bulk of solid materials
4.	classification, distinction and overview of surface characterization techniques
5.	Classification and overview of bulk characterization techniques
6.	Overview of techniques for atomic structure and surface morphology determination.
7.	Working principle of X-ray Diffraction (XRD)
8.	Indexing of XRD patterns (Cubic)
9.	Indexing of XRD patterns (non-Cubic)
10.	Crystallite size estimation using XRD patterns
11.	Estimation of lattice parameters from XRD patterns
12.	Introduction to transmission electron microscopy (TEM)
13.	Low energy electron diffraction (LEED)
14.	Indexing of Selected Area Diffraction Patterns in TEM
15.	Introduction to scanning tunneling microscopy (STM)
16.	Introduction to atomic force microscopy (AFM).
17.	Problem solving and discussion on Module 2
18.	Problem solving and discussion on Module 2
19.	Problem solving and discussion on Module 2
20.	Introduction to techniques for compositional analysis
21.	Working principle and data analysis for the techniques- electron probe micro analysis (EPMA)
22.	Energy dispersive analysis (EDAX) and
23.	Wavelength dispersive analysis (WDS)
24.	Introduction and applications of X-ray fluorescence (XRF)
25.	Problems solving, data analysis on Module 3
26.	Problems solving, data analysis on Module 3
27.	Problems solving, data analysis on Module 3
28.	Introduction to Thermal analysis and other techniques
29.	working principle and data analysis for thermal techniques- differential scanning calorimetry (DSC),
30.	differential thermal analysis (DTA)
31.	thermo-gravimetric analysis (TGA),
32.	Measurements using Hall Effect technique
33.	Measurements using four-probe technique
34.	Low temperature and high-temperature measurements
35.	Problems solving, data analysis on Module 4
36.	Problems solving, data analysis on Module 4
37.	Problems solving, data analysis on Module 4
38.	Problems solving, data analysis on Module 4
39.	Review of classwork and concepts

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT801	Spintronics for Quantum Technology	3	3	0	0	0

PREREQUISITE – Solid State Physics

COURSE OBJECTIVE(s)
Impart fundamentals knowledge to masters' students in the field of Spintronics and spin-based devices. Describe (phenomenologically) the principal phenomena behind spin-based electronics. Developing capability to use fundamental knowledge in application, and to solve problems independently based on these concepts.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

History and overview of spin electronics, classes of magnetic materials, quantum mechanics of spin, spin-orbit interaction, exchange bias, spin relaxation mechanisms, pure spin and charge currents.

(No. of lectures: 10)

Spin-Hall effect and inverse spin-Hall effect, spin Seebeck effect, magneto caloric effect, the spin galvanic effect, basic electron transport, spin-dependent electron transport, spin-dependent tunneling, the basic theory of Andreev reflection, ferromagnet/ superconductor/ ferromagnet double junctions. Semiclassical transport models, spin injection, spin accumulation, spin current.

(No. of lectures: 10)

Spin-transfer torque and its magnetic dynamics, current-driven switching of magnetization and domain wall motion, domain wall scattering and current-induced switching in ferromagnetic wires. basics of spin valve and magnetic tunnel junctions, tunnel magneto resistance, quantum mechanical model of coherent tunnelling and giant TMR, read heads, MRAMS, spin transistors, spintronic biosensors.

(No. of lectures: 12)

History of quantum computation and quantum information, quantum bits and quantum circuits, quantum computation and quantum measurements, nanostructures for quantum electronics, Spin-based qubits: principle and working.

(No. of lectures: 7)

Recommended Readings

Text books –

1. Introduction to Spintronics, S. Bandyopadhyay, M. Cathay, CRC Press, 2008.
2. Magnetoelectronics, M. Johnson, Academic Press 2004.
3. Concepts in Spin Electronics, S. Maekawa, Oxford University Press, 2006.
4. Quantum Computation and Quantum Information, Michael A. Nielsen, and Isaac L. Chuang, Cambridge University Press, 2010
5. Introduction to Quantum Information Science, Vlatko Vedral, Oxford University Press, 2006.

Reference books –

1. Spintronic materials and technology, Y.B. Xu and S. M. Thompson, Taylor & Francis, 2006.
2. Magnetic Recording Technology, C.D. Mee and E.D. Daniel, McGraw-Hill Professional (1996).
3. Semiconductor Spintronics and Quantum Computation, D. D. Awschalom, D. Loss, N. Samarth, Springer Berlin Heidelberg (2010)

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction to the course syllabus
2.	History and overview of spin electronics
3.	Classes of magnetic materials
4.	Quantum mechanics of spin
5.	Spin-orbit interaction
6.	Exchange bias
7.	Spin relaxation mechanisms,
8.	Pure spin and charge currents.
9.	Overview of magnetic structure of materials
10.	Spin-Hall effect and inverse spin-Hall effect,
11.	Basic electron transport,
12.	Spin-dependent electron transport
13.	Spin-dependent tunneling, the basic theory of Andreev reflection,
14.	Ferromagnet/ superconductor/ ferromagnet double junctions.
15.	Semiclassical transport models,
16.	Spin injection, spin accumulation,
17.	Introduction to spin currents.
18.	Problem solving and discussion on Module 2
19.	Introduction to Spin-electronics
20.	Spin-transfer torque and its magnetic dynamics
21.	Current-driven switching of magnetization
22.	Domain wall motion and domain wall scattering
23.	Current-induced switching in ferromagnetic wires.
24.	Basics of spin valve and magnetic tunnel junctions,
25.	Tunnel magneto resistance
26.	Quantum mechanical model of coherent tunnelling and giant TMR
27.	Read heads, MRAMS
28.	Spin transistors
29.	spintronic biosensors
30.	Problem solving and discussion on Module 3
31.	History of quantum computation and quantum information
32.	quantum bits and quantum circuits
33.	quantum bits and quantum circuits
34.	Quantum computation and quantum measurements
35.	Quantum computation and quantum measurements
36.	nanostructures for quantum electronics
37.	Spin-based qubits: principle and working.
38.	Spin-based qubits: principle and working.
39.	Review of classwork and concepts

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT819	**Solar Energy and Applications**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – Solid State Physics, Materials Science

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of solar energy resource, solar energy conversion techniques, basics of semiconductor junction, design and operation of solar cells, performance testing and analyses.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Renewable and non-renewable energy resources, solar energy: origin, solar constant, spectral distribution of solar radiation, absorption of solar radiation in the atmosphere, global and diffused radiation, seasonal and daily variation of solar radiation, measurement of solar radiation, solar to thermal conversion, types of solar energy collectors, concentrating/non-concentrating solar collectors, collector efficiency and its dependence on various parameters, solar fuels: electrolysis of water, photoelectrochemical splitting of water.

(No. of lectures: 12)

Fundamentals of solar cells: photo voltaic effect, p-n junction photodiodes, depletion region, electron and holes transports, absorption of photons, excitons and photoemission of electrons, band engineering, charge carrier generation, charge separation, recombination and other losses

(No. of lectures: 10)

I-V characteristics, output power, efficiency, fill factor and optimization for maximum power, metal-semiconductor heterojunctions, surface structures for maximum light absorption, operating temperature vs conversion efficiency.

(No. of lectures: 10)

Device physics, device structures, device construction, solar cell properties and design, materials for solar cells, silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells, organic solar cells, organic-inorganic hybrid solar cells, advanced concepts in photovoltaic research, nanotechnology applications, plasmonic based solar cells.

(No. of lectures: 7)

TEXT/ REFERENCE BOOKS: -

1. Nelson, J. The Physics of Solar Cells. Imperial College Press, 2003. ISBN: 9781860943409.
2. Solar Engineering of Thermal Process: Duffie and Beckman, John Wiley, 2013. ISBN: 9780470873663
3. Solar Energy: S. P. Sukhatme, Tata McGraw Hill, 1996. ISBN: 1259081966, 9781259081965.
4. Principles of Solar Engineering, D. Yogi Goswami, Taylor and Francis, 2015. ISBN: 9781138569478.
5. Wenham, S., M. Green, et al., eds. Applied Photovoltaics. 2nd Ed. Routledge, 2006. ISBN: 9781844074013.
6. Green, M. A. Solar Cells: Operating Principles, Technology, and System Applications. Prentice Hall, 1981. ISBN: 9780138222703.

Lecture Plan

Lecture No.	Topics to be covered
1.	Renewable and non-renewable energy resources
2.	Introduction to Solar energy: origin
3.	Solar resource
4.	Spectral distribution of solar radiation, absorption in atmosphere
5.	Concept of Air Mass, quantification of solar radiation
6.	Seasonal and daily variation of solar radiation, long- and short- term constants
7.	Solar irradiation measurement techniques: space based and ground based;
8.	Solar to thermal energy conversion systems
9.	Solar concentrators and types
10.	Collector efficiency and its dependence on various parameters
11.	Solar to thermal to electrical energy conversion
12.	Solar fuels: hydrogen, Hydrogen production processes
13.	Hydrogen generation: Electrolysis of water
14.	Hydrogen generation: Photoelectrochemical (PEC) splitting of water
15.	Fundamentals of solar cells: photo voltaic effect
16.	p-n junction photodiodes, Depletion region, electron and holes transports
17.	Absorption of photons
18.	Surface structures for maximum light absorption
19.	Thermalization losses
20.	Concept of multijunction solar cells
21.	Review of classes, resolving queries
22.	Semiconductor band engineering
23.	Charge carrier generation and transport
24.	Charge separation
25.	Recombination and other losses, and time constants
26.	I-V characteristics of a diode: under dark and illumination
27.	Output power, types of efficiencies
28.	Fill factor and optimization for maximum power
29.	Metal-semiconductor junctions
30.	Operating temperature vs conversion efficiency
31.	Introduction to device physics: Device structures
32.	Introduction to device physics: Device construction
33.	Solar cell properties and design
34.	Materials for solar cells
35.	Silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells
36.	Advanced concepts in PV: Organic solar cells, organic-inorganic hybrid
37.	Advanced concepts in photovoltaic research: perovskite based solar cells
38.	Nanotechnology applications and quantum dots
39.	Plasmonic based solar cells

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT802	**Energy Materials and Devices**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – None

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of renewable energy resource, energy conversion techniques, hydrogen energy, energy storage devices, batteries, fuel-cells, working principle and device structure.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Energy units, Energy requirements, Natural sources, Renewable and nonrenewable sources, Types of energy devices-generation, storage, conversion and transport, Concepts, definitions and essential performance parameters. Introduction to hydrogen as a green fuel, Water splitting technologies for hydrogen and oxygen generation, Electrochemical water splitting; free energy adsorption, volcano plot, Basic reaction mechanism, Energy level diagram, Photochemical cell designs, fabrication and performance analysis

(No. of lectures: 10)

Introduction to solar energy and solar resource, optical absorption and losses, charge generation, charge separation, charge collection, 1-D device model, Important parameters in photovoltaics (Describing J-V characteristics, Spectral response-EQE & IQE), Shockley-Queisser limit, photon management), single and multi-junction tandem solar cells, Energy level diagrams

(No. of lectures: 6)

Capacitor & supercapacitor, Concept of EDLC, Basic electrochemical concepts and definitions, Pseudo and asymmetric supercapacitors, Microsupercapacitors, Li-ion capacitors, comparison of performances and application areas, Primary and secondary batteries, Principle of operation, Conventional batteries, Li-ion and beyond Li-ion other batteries, Battery components and design of electrodes, cell and battery fabrication, Measurements- CD curves, priming & cycling, time scales, charge retention, coulombic efficiency, self-discharge & charge retention, long term stability

(No. of lectures: 14)

Hybrid battery-supercap devices, electric mobility, Building block cells, battery/supercap modules and packs, voltage and current management, all solid-state batteries & new concepts in Batteries beyond lithium, smart photorechargeable batteries; basic concepts of fuel-cells, Types of fuel cells, fuels for fuel cell, catalysts, membranes fuel cell design.

(No. of lectures: 09)

TEXT/ REFERENCE BOOKS: -

1. Energy Materials: Fundamentals to Applications, Sanjay J. Dhoble, N. Thejo Kalyani, B. Vengadaesvaran, Abdul Kariem Arof, Elsevier, 2021, ISBN: 0128237112, 9780128237113.
2. Introduction to Materials for Advanced Energy Systems, Colin Tong, Springer Cham, 2019, ISBN: 978-3-319-98001-0.
3. Green, M. A. Solar Cells: Operating Principles, Technology, and System Applications. Prentice Hall, 1981. ISBN: 9780138222703.
4. Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications, B. E. Conway, 1999, ISBN: 978-0-306-45736-4
5. Fuel Cells and Hydrogen: From Fundamentals to Applied Research, Viktor Hacker, Shigenori Mitsushima, 2018, ISBN: 9780128114599.

Lecture Plan

Lecture No.	Topics to be covered
1.	General introduction: Energy units, Energy requirements,
2.	Natural sources, Renewable and nonrenewable sources
3.	Types of energy devices-generation, storage, conversion and transport,
4.	Concepts, definitions and essential performance parameters
5.	Electrodes and active materials, Carbon and related electrodes
6.	Transparent conducting electrodes
7.	Introduction to hydrogen as a green fuel, Hydrogen production technologies
8.	Water splitting technologies for hydrogen and oxygen generation
9.	Basics of the photocatalytic mechanisms of water and other related systems
10.	Electrochemical water splitting; free energy adsorption, volcano plot,
11.	Introduction to solar energy and solar resource
12.	optical absorption and losses
13.	charge generation, charge separation
14.	charge collection, 1-D device model
15.	PV Working principle, classification,
16.	Shockley-Queisser limit, photon management, Thin Film Solar Cells
17.	Capacitor & supercapacitor, Concept of EDLC
18.	Pseudocapacitors
19.	Electrodes and electrolytes for supercapacitors
20.	Basic electrochemical concepts and definitions of supercapacitors
21.	Li-ion capacitors, comparison of performances and application areas
22.	Microsupercapacitors
23.	Fabrication processes
24.	Primary and secondary batteries, Principle of operation
25.	Conventional batteries, Li-ion and other batteries
26.	Battery components and design of electrodes, cell and battery fabrication
27.	Measurements- CD curves, priming & cycling, time scales, charge retention,
28.	coulombic efficiency, self-discharge & charge retention, long term stability
29.	Ragone plot: energy and power densities, performance comparison
30.	Introduction to Electrochemical Impedance Spectroscopy (EIS), Series and Parallel circuits, Nyquist plots
31.	Hybrid battery-supercap device, electric mobility
32.	Building block cells, battery and supercap modules and packs,
33.	Voltage and current management
34.	All solid-state batteries & new concepts in Batteries beyond lithium
35.	Basic concepts of fuel-cells
36.	Types of fuel cells
37.	Fuels for fuel cell
38.	Catalysts, Membranes, Fuel cell design
39.	Course review, resolving queries, and conclusion

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT803	**Basics of Astronomy & Astrophysics**	**3**	**3**	**0**	**0**	**0**

PREREQUISITES: Thermodynamics, Classical Mechanics & Quantum Mechanics.

COURSE OBJECTIVES:

1. To impart fundamentals and application based knowledge education to Masters' students of Physics, primarily in areas: Astronomy & Astrophysics.
2. To enable students to solve problems independently based on these concepts.
3. To equip students with the basics of the field so that they may pursue it as a career.
4. To have periodic evaluation of students through class work sessionals / mid-term and end term examinations.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Astronomy - Coordinate Systems for Celestial Objects & Their Interrelations, Cardinal Points In The Sky, Time Measurements in Astronomy, Proper & Peculiar Motion of Stars, Astronomical Observations and Instruments, Parallaxes, Photometry, Magnitude System, Distance Modulus, Color Indices;

(No. of lectures: 13)

Astrophysics-I - Stellar spectra and Structure, Ionization Equation & Elemental Abundances, H-R Diagram, Stellar Evolution, Nucleosynthesis and Formation of Elements, Variable stars, Compact stars, Star clusters and Binary stars;

(No. of lectures: 13)

Astrophysics-II - Galaxies & their Evolution and Origin, Milky Way & Spiral arm, Hubble Classification of Galaxies: elliptical, spiral & irregular, Galaxy Distance & Cosmic Ladder, Active Galaxies and Quasars, Starburst galaxies, Dark matter: Galaxy mass , Galaxy Clusters & Superclusters.

(No. of lectures: 13)

TEXT BOOKS/ REFERENCE BOOKS: -

1. An Introduction to Modern Astrophysics: by B. W. Carrol & D. A. Ostlie (Addison Wesley)
2. Textbook of Astronomy & Astrophysics with Elements of Cosmology: V. B. Bhatia (Narosa)
3. An introduction to astronomy & cosmology: by Ian Morrisson (John Wiley)
4. An Introduction to Astrophysics, B. Basu, T. Chattopadhyay, S.N. Biswas

Lecture Plan

Lecture No.	Topics to be covered
1.	Horizontal Coordinate Systems
2.	Equatorial Coordinate System
3.	Ecliptic Coordinate System
4.	Galactic Coordinate System
5.	Astronomical Time
6.	Fixed points in the sky
7.	Stellar motions
8.	Optical instruments
9.	Parallax
10.	Stellar Magnitude
11.	Distance Modulus
12.	Photometry
13.	Color Indices
14.	Stellar spectra and Structure
15.	Ionization Equation & Elemental Abundances
16.	Stellar Evolution
17.	Nucleosynthesis and Formation of Elements
18.	Variable stars
19.	Contd.
20.	Contd.
21.	Compact stars
22.	Contd.
23.	Star clusters
24.	Contd.
25.	Binary Stars
26.	Galaxies & their Evolution and Origin
27.	Milky Way Spiral Arm
28.	Hubble Classification of Galaxies
29.	Elliptical, Irregular
30.	Spiral
31.	Active Galaxies and Quasars
32.	Starburst Galaxies
33.	Galaxy Distance & Cosmic Ladder
34.	Dark Matter
35-37.	Galaxy Mass
38.	Galaxy Clusters
39.	Galaxy Superclusters

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT816	**Plasma Physics**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – Classical Mechanics, Electrodynamics

COURSE OBJECTIVE(s)

After successfully completing this course student should be able to understand plasma as a fourth state of matter. They shall learn the appropriate techniques to deal with with tenuous / dense plasma regimes. They will learn about the waves & instabilities grown in plasma. Basic applications of plasma in the fields of space propulsion / nuclear fusion shall also be learned.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
1.	Internal assessment (based upon assignments, quizzes and attendance)	20%
2.	Mid-term examination	30%
3.	End Semester Examination	50%

COURSE CONTENTS

Basic properties, occurrence of plasma, criteria for plasma behavior, plasma oscillations, quasineutrality, Debye shielding, plasma parameters

(No. of lectures: 8)

Charged particle motion and drifts, guiding center motion of charged particles, motion in uniform electric and magnetic fields, motion in non-uniform magnetic field, principle of magnetic mirror, loss cone, motion in non-uniform electric field for small Larmor radius, time varying electric field, time varying magnetic field, adiabatic invariance of magnetic moment

(No. of lectures: 14)

Brief discussion of methods of plasma production, DC discharge, RF discharge, Photoionization, plasma diagnostics, Langmuir probe.

(No. of lectures: 5)

Plasma as fluids, equation of motion, convective derivative, Waves in plasma, Electrostatic waves Instabilities, two stream instability. Collision and diffusion parameters, Fick's Law. Fusion energy, Lawson criterion, Controlled fusion schemes (Tokamak, ITER). Principle of MHD power

(No. of lectures: 12)

TEXT/ REFERENCE BOOKS:-

1. Introduction to Plasma Physics and Controlled Fusion: Francis F. Chen (Springer).
2. Principles of Plasma Physics for Engineers and Scientists: Umran Inan and Marek Golkowski (CambridgeUniversity Press).
3. Fundamentals of Plasma Physics: Paul M. Bellan (Cambridge University Press)).
4. Introduction to plasma Physics: R. J. Goldston & P. H.Rutherford (IoP Publication).

Lecture Plan

Lecture No.	Topics to be covered
1.	Basic properties
2.	occurrence of plasma
3.	criteria for plasma behavior
4.	plasma oscillations
5.	quasineutrality
6.	Debye shielding
7.	plasma parameters
8.	Contd.
9.	Charged particle motion and drifts
10.	guiding center motion of charged particles
11.	motion in uniform electric and magnetic fields
12.	Cross drift & Hall Thrusters
13.	motion in non-uniform magnetic field
14.	Gradient drift
15.	Curvature Drift
16.	principle of magnetic mirror, loss cone
17.	motion in non-uniform electric field for small Larmor radius,
18.	time varying electric field,
19.	time varying magnetic field,
20.	adiabatic invariance of magnetic moment
21.	Other adiabatic invariants
22.	Recap.
23.	Brief discussion of methods of plasma production
24.	DC discharge
25.	RF discharge
26.	Photoionization
27.	plasma diagnostics, Langmuir probe.
28.	Plasma as fluids
29.	convective derivative
30.	EoM
31.	Waves in plasma
32.	Electrostatic waves Instabilities
33.	two stream instability
34.	Collision and diffusion parameters
35.	Fick’s Law
36.	Fusion energy
37.	Lawson criterion,
38.	Controlled fusion schemes (Tokamak, ITER)
39.	Principle of MHD power generation

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT806	**General Theory of Relativity**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)

This course aims to introduce the basic concepts and formalism of general theory of relativity. The course will also cover basic cosmology, and generation and detection of gravitational waves.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Why general relativity, Review of special theory of relativity: Inertial observers, Minkowski metric, spacetime diagrams, light cone, invariant hyperbolae, Lorentz transformations, vectors and vector spaces, Four-vector formulation of special relativity, Tensors and tensor manipulation, Energy and momentum in special relativity and energy-momentum tensor for perfect fluid.

(No. of lectures: 10)

Riemannian geometry: manifolds, curve on a manifold, functions on manifolds, vectors and vector fields on manifolds, tensors on manifolds, metric tensor and tensor densities, tensor calculus, Christoffel symbols and covariant derivative, parallel transport and geodesics, Riemann curvature tensor, general properties of Riemann tensor, Ricci tensor and scalar, Weyl tensor. Geodesic deviation

(No. of lectures: 12)

Equivalence principle, principle of general covariance, Physics in curved spacetime, Conservation of energy-momentum tensor in curved spacetime. geodesics as trajectories under the influence of gravitational field, Weak field limit of geodesic equation, Einstein's field equation.

(No. of lectures: 5)

Schwarzchild solutions of Einstein's field equation, construction of metric and its symmetries, motion of a particle in Schwarzchild metric, experimental tests of general relativity, precession of the perihelion, bending of light, gravitational redshift, singularities, horizons, black holes. FRW metric, Friedmann equation, Radiation and matter dominated universe, Cosmological Constant, Inflation and CMBR

(No. of lectures: 7)

Gravitation radiation: Weak field approximation, Gauge transformations, Degrees of freedom, Plane gravitational waves solutions, Generation of gravitational waves, quadrupole radiation, Energy loss due to gravitational waves, Detection of gravitational waves.

(No. of lectures: 5)

Recommended Readings

Text books –

1. A First Course in General Relativity: Bernard Schutz (Cambridge University Press).
2. Spacetime and Geometry: An Introduction to General Relativity, Sean M. Carroll (Pearson Indian Education)
3. Gravity: An introduction to Einstein's General Relativity; J. B. Hartle (Pearson India Education)
4. Introducing Einstein's Relativity: Ray D'Inverno (Oxford University Press).

Reference Books-

1. General Relativity: R. M. Wald (University of Chicago Press).
2. Gravitation and Cosmology: S. Weinberg (Wiley India PVT. LTD).
3. Classical Theory of Fields: L. D. Landau and E. M. Lifshitz (CBSPD).

Lecture Plan

Lecture No.	Topics to be covered
1	Motivation and introduction: Recap of Newtonian gravity, gravity as curvature of spacetime
2	Motivation and introduction continued: areas where general relativity is applied.
3	Spacetime, Inertial observer, Minkowski metric
4	Spacetime diagrams, lighcone and intervals, invariant hyperbolae,
5	Time dilation and length contraction in terms of spacetime diagrames. Lorentz transformations. Vectors, vector fields
6	Recap of vector spaces: basis, subspaces, linear functionals, dual basis
7	Vectors in Minkowski spacetime, contravaiant and covariant vectors, vector fields
8	Tensors in Minkowski spacetime,Metric tensor and inner product, Levi-Civita symbol.
9	Tensor manupulations: Contraction, symmetization, raising and lower of indices, differential forms
10	Energy and momentum in special relativity, Energy-momentum tensor for a perfect fluid and continuity equation in covarinat form
11	Manifolds: open sets, coordinates and charts, atlas
12	Coordinate transformations, Examples of manifolds such as R^n and S^2
13	Curves on manifolds, functions on manifolds., Vectors and vector fields on manifolds, tangent vector and tangent space, coordinate basis
14	Co-tangent space, tensors and tensor fields on manifolds. Metric tensor on manifolds, distances on manifolds.
15	Metric in curved spacetime, example of metric on 2-sphere, tensor densities.
16	Covariant derivative and connections
17	Christoffel symbols and their properties
18	Parallel transport and directional covariant derivative, geodesic equation
19	Proper time and geodesic from variational method, Local Lorentz frames
20	Riemann curvature tensor
21	Properties of Riemann curvature tensor
22	Ricci tensor and Ricci scalar, Geodesic deviation
23	Principle of Equivalence and Principle of general Covarience
14	Conservation of energy-momentum in curved space time. geodesics as trajectories under the influence of gravitation
25	Weak field limit of geodesic equation
26	Einstein’s field equation
27	Properties of Einstein’s field equation
28	Schwartzschild’s solution of Einstein’s field equation
29	Construction of metric and its symmetries, Killing vector
30	Motion of a particle in Schwartzchild metric, Experimental tests of general relativity, precession of perihilion of Mercury.
31	Precession of perihilion continued, bending of light, gravitational redshift
32	Singularities, horizons and black holes

33	FRW metric and Friedmann equations
34	Radiation and matter dominated universe, Cosmological Constant, Inflation and CMBR
35	Weak field approximation, Gauge transformations
36	Degrees of freedom, Plane gravitational waves solutions
37	Generation of gravitational waves, quadrupole radiation
38	Energy loss due to gravitational waves
39	Detection of gravitational waves

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT804	**Introduction to Monte Carlo Simulation**	**3**	**2**	**0**	**2**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)
This course aims to provide the students with basic concepts and advanced topics of MonteCarlo Simulation.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Fundamentals of Monte Carlo approach to simulate the particle interactions with detector materials, random number generation, landau distribution of energy deposited, convolution with Poisson distribution, advantages of Monte Carlo method, basic Geant4 concepts, important features of Geant4, installation.

(No. of lectures: 7)

User classes: mandatory classes and action classes, detector construction, physics processes: electromagnetic, hadronic and decays, generation of primary particles through gun, action classes:run, event and tracking of particles in the experiment, Geant4 examples: basic, extended and advanced examples, design of simple geometry e.g. calorimeter to the real life experiment e.g. hadron therapy.

(No. of lectures: 8)

Hands on sessions on how to design the experiment, compile and run in geant4 simulation environment, analysis of simulated data from Geant4 using ROOT software: 1D, 2D and 3D histogram plotting, curve fitting, storing data in Tree and Ntuples, applications: computed tomography, 3D image reconstruction in medical physics, design optimization of any complex detector geometry in high energy physics experiments, radiation effects analysis in space science, application in solid state physics.

(No. of lectures: 11)

Recommended Readings

Text books-

1. Statistics: R J Barlow (John Wiley and Sons)
2. A Practical Guide to Data Analysis for Physical Science Students –L. Lyons (Cambridge University Press)
3. Data analysis techniques for HEP, Fruhwirth et al (Cambridge University Press)
4. Advanced Monte Carlo for Radiation Physics, Particle Transport Simulation and Applications: I. Kawrakow, in A. Kling et al (edts.) (Springer).
5. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
6. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
7. Handbook of Radiotherapy Physics, Theory and Practice: P Mayles, A Nahum, J.C Rosenwald (Taylor & Francis).

Online resources-

1. Monte Carlo simulations, Geant4 User Guide: http://www.cern.ch/geant4
2. Data Analysis Software, ROOT User Guide: https://root.cern.ch/

Lecture Plan

Lecture No.	Topics to be covered
1.	Fundamentals of Monte Carlo approach to simulate the particle interactions with detector materials
2.	Random number generation
3.	Landau distribution of energy deposited
4.	Convolution with Poisson distribution
5.	Advantages of Monte Carlo method, basic Geant4 concepts, important features of Geant4
6.	Advantages of Monte Carlo method, basic Geant4 concepts, important features of Geant4
7.	Installation
8.	User classes: mandatory classes and action classes, detector construction
9.	User classes: mandatory classes and action classes, detector construction
10.	Physics processes: electromagnetic, hadronic and decays, generation of primary particles through gun
11.	Physics processes: electromagnetic, hadronic and decays, generation of primary particles through gun
12.	Action classes:run, event and tracking of particles in the experiment, Geant4
13.	Action classes:run, event and tracking of particles in the experiment, Geant4
14.	Geant4 examples: basic, extended and advanced examples, design of simple geometry e.g. calorimeter to the real life experiment e.g. hadron therapy
15.	Geant4 examples: basic, extended and advanced examples, design of simple geometry e.g. calorimeter to the real life experiment e.g. hadron therapy
16.	Hands on sessions on how to design the experiment, compile and run in geant4 simulation environment
17.	Hands on sessions on how to design the experiment, compile and run in geant4 simulation environment
18.	1D, 2D and 3D histogram plotting
19.	1D, 2D and 3D histogram plotting
20.	Curve fitting, storing data in Tree and Ntuples
21.	Curve fitting, storing data in Tree and Ntuples
22.	Computed tomography
23.	3D image reconstruction in medical physics
24.	Design optimization of any complex detector geometry in high energy physics experiments
25.	Radiation effects analysis in space science
26.	Application in solid state physics

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT805	**Machine Learning in Physics**	**3**	**2**	**0**	**2**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)
This course aims to provide students with programming knowledge from basics of Python to the advanced level of Machine Learning using Python.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Machine learning software packages (open sources, e.g., python) and their installation, Basics of Python, Supervised and Unsupervised learning.

(No. of lectures: 3)

Regression, Classification, Principal component analysis, Singular value decomposition, Support vector machines, Clustering, K-Nearest Neighbors, Decision trees, Neural Networks, Deep Learning.

(No. of lectures: 16)

Applications of machine learning in physics research, Preparation of mini projects in the interdisciplinary field of physics such as Statistical Physics, Electromagnetism, Nuclear Physics, Device Physics etc.

(No. of lectures: 7)

Recommended Readings

TEXTBOOKS/ REFERENCE BOOKS: -

1. Introduction to Machine Learning, 3rd ed., E. Alpaydin, MIT Press (2014)
2. Introduction to Machine Learning with Python, Andreas C. Müller & Sarah Guido
3. Python Machine Learning - Second Edition, Sebastian Raschka , Vahid Mirjalili
4. Data Analysis Software, ROOT User Guide: https://root.cern.ch/
5. Statistics: R J Barlow (John Wiley and Sons)
6. A Practical Guide to Data Analysis for Physical Science Students –L. Lyons (Cambridge University Press)
7. Data analysis techniques for HEP, Fruhwirth et al (Cambridge University Press)
8. The Elements of Statistical Learning, 2nd ed., T. Hastie, R. Tibshirani, & J. Friedman, Springer (2016)
9. Handbook of Radiotherapy Physics, Theory and Practice: P Mayles, A Nahum, J.C Rosenwald (Taylor & Francis)
10. Hands-On Machine Learning: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition, Aurélien Géron

Lecture Plan

Lecture No.	Topics to be covered
1.	Machine learning software packages (open sources, e.g., python) and their installation
2.	Basics of Python
3.	Regression, Classification
4.	Regression, Classification
5.	Regression, Classification
6.	Principal component analysis, Singular value decomposition
7.	Principal component analysis, Singular value decomposition
8.	Support vector machines
9.	Support vector machines
10.	Clustering
11.	Clustering
12.	K-Nearest Neighbors
13.	K-Nearest Neighbors
14.	Decision trees
15.	Decision trees
16.	Neural Networks
17.	Neural Networks
18.	Deep Learning
19.	Deep Learning
20.	Applications of machine learning in physics research
21.	Applications of machine learning in physics research
22.	Preparation of mini projects in the interdisciplinary field of physics
23.	Preparation of mini projects in the interdisciplinary field of physics
24.	Preparation of mini projects in the interdisciplinary field of physics
25.	Preparation of mini projects in the interdisciplinary field of physics
26.	Preparation of mini projects in the interdisciplinary field of physics

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT809	Introduction to Quantum Field Theory	3	2	1	0	0

PREREQUISITE COURSES
Advanced Quantum Mechanics

COURSE OBJECTIVES

Students will learn the development of Quantum Field Theory from first principles. They will also learn to develop theories of practical importance, as well as understand the underlying framework that leads to the modern understanding of microscopic matter and forces.

COURSE ASSESSMENT

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Introduction: Basics of Special Relativity, Lorentz and Poincare group, problems with old relativistic quantum theory

(No. of Lectures: 3)

Free spinless particles: classical theory of scalar fields, Klein-Gordon equation, Noether’s Theorem, canonical quantisation of Klein-Gordon theory, propagators and Green’s functions, complex scalar theory and anti-particles, discrete symmetries

(No. of Lectures: 9)

Interacting spinless particles: Interacting scalar fields, path integrals, cross sections and S-matrix, LSZ reduction formula, perturbation theory and Feynman diagrams, Wilson's approach to renormalization

(No. of Lectures: 9)

Particles with spin: relativistic origins of spin and Dirac algebra, Dirac fields, problem with standard commutation relations and fermions, brief introduction to Quantum Electrodynamics

(No. of Lectures: 5)

TEXT BOOKS

1. An Introduction To Quantum Field Theory, Michael E. Peskin & Daniel V. Schroeder (CRC Press)
2. Quantum Field Theory, Mark Srednicki (Cambridge University Press)

REFERENCE BOOKS & NOTES

1. The Quantum Theory of Fields: Steven Weinberg (Cambridge University Press)
2. David Tong's lecture notes on QFT
3. Quantum Field Theory In A Nutshell, A. Zee (Princeton University Press)
4. Classical Theory of Gauge Fields, Valerie Rubakov (Princeton University press)

Lecture Plan

Lecture No.	Topics to be covered
	Unit 1: Introduction
1.	Crash course in Special Relativity
2.	Lorentz and Poincare groups
3.	Failures of old relativistic quantum theory
	Unit 2: Free spinless particles
4.	Classical theory of scalar fields – least action principle, lagrangian formulation
5.	Equation of motion, Noether's theorem
6.	Noether's theorem contd. - some examples
7.	Canonical quantisation of free scalar theory, spin
8.	Interpretations of various objects in the theory, energy states
9.	Green's functions of the free theory
10.	Connection with propagators and their interpretations
11.	Complex scalar theory, particles and anti-particles
12.	Discrete symmetries
	Unit 3: Interacting spinless particles
13.	Path integrals – need and introduction
14.	Path integrals - convergence, Feynman presciption, return to propagators
15.	Connection with collider experiments – cross section
16.	Connection with collider experiments – S-matrix
17.	LSZ reduction formula
18.	Simple example of perturbation theory - Feynman diagrams
19.	Simple example of perturbation theory – naive renormalization
20.	Wilson's approach to renormalisation
21.	Running coupling constants
	Unit 4: Particles with spin
22.	Spinor fields, Dirac algebra
23.	Relativistic origins of spin, observables of Dirac theory
24.	Quantisation of Dirac theory - problem with standard commutation relations
25.	Quantization of Dirac theory - anti-commutation relations, fermions
26.	Overview of Quantum Electrodynamics

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT812	**Nanostructured Materials and Applications**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE
None

COURSE OBJECTIVE(s)
This course gives an overview of nanomaterials. After successful completion of this course, the student should be able to understand the fundamentals, synthesis, characterization, and applications of nanostructured materials. Students would learn the size-dependent properties of nanomaterials and characterization techniques such as XRD, AFM, SEM, TEM, etc. Students will be able to understand how to analyze and interpret the data obtained from various characterization techniques and future challenges of nanomaterials.

COURSE OUTCOMES:

CO1	It gives an overview of Nanoscience and Nanotechnology
CO2	To understand the size dependent properties and applications of nanomaterials
CO3	To learn about the various synthesis and characterization methods of nanomaterials
CO4	It helps to analyze the data obtained from XRD, AFM, SEM, and TEM

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade) will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Basics of nanoscience & nanotechnology- Overview of nanostructures, top-down and bottom-up approaches, size-dependent properties of nanomaterials, zero, one and two-dimensional nanostructures, density of states, physics of 2D materials, growth mechanism of nanoparticles, superlattice structures, structural, optical, electrical, dielectric, and chemical properties of nanomaterials.

(No. of lectures: 12)

Synthesis and Characterization of Nanomaterials- Synthesis of nanostructured materials using various methods: RF/DC sputtering, Electron beam evaporation, Pulsed Laser Deposition, Ball milling, lithography, CVD, Sol-gel, spin coating. Tailoring of nanomaterials' properties, Modification of nanomaterials using ion implantation and high energy ion irradiation, analysis of nanostructured materials using XRD, STM, AFM, Raman, Dynamic light scattering, Photoluminescence, SEM, and TEM.

(No. of lectures: 20)

Applications of Nanomaterials - Applications of nanotechnology in energy, space, medicine, agriculture, and electronics. Environmental, health, and safety issues, Limitations, challenges, and future aspects of nanotechnology.

(No. of lectures: 7)

TEXT BOOKS/ REFERENCE BOOKS: -

1. Introduction to Nanotechnology: Charles P. Poole, Jr. and Frank J. Owens (Wiley).
2. Nanostructures and Nanomaterials Synthesis, Properties and Applications: G. Cao (Imperial College Press-2006).
3. Introduction to Nanoscience and Nanotechnology, K K Chattopadhyay & A N Banerjee (PHI, EEE, October 2012)
4. Nanotechnology: Basic Science & Emerging Technology: M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse (Overseas Press-2005).
5. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni (Springer)

Lecture Plan

Lecture No.	Topics to be covered
1	Overview of nanostructures
2	Top-down and bottom-up approaches
3	Size-dependent properties of nanomaterials
4	Zero, one and two-dimensional nanostructures
5-6	Density of states
7	Physics of 2D materials
8	Growth mechanism of nanoparticles
9	Superlattice structures
10	Properties of nanomaterials: structural, optical, electrical
11	Dielectric, and chemical properties of nanomaterials
12	Problems on nanomaterials
13	Synthesis of nanostructured materials using various methods: RF/DC sputtering
14	Electron beam evaporation
15	Pulsed Laser Deposition
16	Ball milling
17	Lithography
18	Chemical Vapour Deposition
19	Sol-gel, spin coating
20	Tailoring of nanomaterials' properties
21-22	Modification of nanomaterials using ion implantation and high energy ion irradiation
23-24	Analysis of nanostructured materials using X-Ray diffraction (XRD)
25	Scanning tunnelling microscopy
26	Atomic Force Microscopy
27	Raman spectroscopy
28	Dynamic light scattering
29	Photoluminescence
30	Scanning Electron Microscopy
31-32	Transmission Electron Microscopy
33-35	Applications of nanotechnology in energy, space, medicine, agriculture, and electronics
36-37	Environmental, health, and safety issues
38-39	Limitations, challenges, and future aspects of nanotechnology

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT806	**Soft Materials**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – Understanding of basic material science

COURSE OBJECTIVE(s)

This course is an introduction to soft materials. Soft matter (or soft condensed matter) is a multidisciplinary field: as such, this class includes chemistry, physics, thermodynamics, and materials science content. Applications of the above in life and in research. The goal is to enjoy the science behind these "everyday" applications of soft materials.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Introduction to soft materials and soft matter, generic aspects of soft materials, classification in terms of their thermal, mechanical and often unusual physical properties. examples of soft systems: polymers, foams, granular media, colloids, liquid crystals, micelles, vesicles and biological membranes, Responsive nanomaterials, Self-healing, Hybrid nanoparticles

(No. of lectures: 10)

From hard to soft building blocks, synthesis of hard and soft colloids, hard systems, softer systems and their characterization, dispersion forces, polymers in solution, gels, emulsions and foams, Block copolymers, Soft lithography and micro molding

(No. of lectures: 11)

Controlled drug delivery, Biomimetic engineering, Flexible electronics, Wearable electronic, Organic Electronics, Soft robotics, Soft Electronics Fabrication Approaches, General trends in soft nanomaterials research

(No. of lectures: 09)

Wearable and flexible gas sensors, Types of wearable sensors: Invasive, Non-invasive; Intelligent clothing, Wearable chemiresistive and biochemical Sensors, Detection of atmospheric pollutants, Wearable devices for health monitoring

(No. of lectures: 09)

Recommended Readings Text books

1. Fundamentals of soft matter science: Linda S. Hirst (CRC).
2. Introduction to soft matter: Ian W. Hamle (Wiley).
3. Polymer surfaces and interfaces: M Stamm (Springer).
4. Soft condensed matter: R.A.L. Jones (Oxford)
5. Wearable Sensors: Fundamentals, Implementation and Applications (Elsevier)

Reference books:

1. Soft materials: structure and dynamics: John R. Dutcher, A. G. Marangoni (CRC)

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction to soft materials and soft matter
2.	Generic aspects of soft materials
3.	Classifications of soft materials
4.	Introduction of Colloids
5.	Introduction of polymers
6.	Introduction of liquid crystals
7.	Introduction of micelles and vesicles
8.	Introduction of biological membranes
9.	Responsive nanomaterials
10.	Self-healing, Hybrid nanoparticles
11.	Hard building blocks
12.	Soft building blocks
13.	Synthesis of hard and soft colloids
14.	Hard systems
15.	Softer systems
16.	Dispersion forces
17.	Surface and interfacial organization
18.	Polymers in solution
19.	Gels, emulsions and foams
20.	Block copolymers,
21.	Soft lithography and micro molding
22.	Controlled drug delivery
23.	Biomimetic engineering
24.	Flexible and wearable electronics (Cont)
25.	Flexible and wearable electronics
26.	Organic Electronics
27.	Soft robotics
28.	Soft Electronics Fabrication Approaches (cont)
29.	Soft Electronics Fabrication Approaches
30.	General trends in soft nanomaterials research
31.	Wearables: Challenges and Opportunities.
32.	Motivation for the development of Wearable Devices
33.	The emergence of wearable computing and wearable electronic
34.	Types of wearable sensors: Invasive, Non-invasive; Intelligent clothing
35.	Wearable chemiresistive Sensors
36.	Wearable biochemical Sensors
37.	Detection of atmospheric pollutants
38.	Wearable devices for health monitoring (Cont)
39.	Wearable devices for health monitoring

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT813	**Nanotechnology for Energy Applications**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – Fundamentals of nanomaterial

COURSE OBJECTIVE(s)

This course focuses on the careful selection of nanomaterials for applications in energy harvesting and storage. It explores the challenges associated with enhancing the performance of devices and techniques related to energy harvesting and storage. Throughout the course, various energy harvesting and storage methods will be discussed, along with an examination of the critical parameters involved in the selection of nanomaterials for these applications.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Energy challenge in the 21st century, Introduction of nanotechnology, Synthesis and characterization methods of nanomaterials, Energy storage and energy harvesting technologies, Criteria for choosing the nanomaterials for energy harvesting and storage applications, Application of nanotechnologies in the energy value chain

(No. of lectures: 10)

Renewable and non-renewable energy sources, Development and implementation of renewable energy technologies, Examples of nanotechnology energy production and energy storage, Nanotechnology for Solar Energy Collection and Conversion, Nanotechnology for water technologies, Nanotechnology for water treatment and desalination

(No. of lectures: 10)

Nanomaterials used for hydrogen energy generation, Methods to produce hydrogen energy, Hydrogen production from fossil fuels and biomass, Role of nanotechnology for hydrogen energy generation, Fuel cells, Proton exchange membrane (PEM) cell, Membrane and its type, Membrane fabrication and its engineering, Methods for separation of hydrogen, Membranes for gas separation.

(No. of lectures: 10)

Energy storage, Nanomaterials used for energy storage, Key challenges for energy storage, Solution of key challenges, Type of energy storages, Nanomaterials for Solid State Hydrogen Storage, Hydrogen Detection Technologies for Hydrogen Safety

(No. of lectures: 09)

Recommended Readings Text books

1. Nanotechnology for the energy challenge, Javier Garcia-Martinez (WILEY- VCH)
2. Renewable energy resources: John Twidell, Anthony D. Weir (Taylor and Francis).
3. Hydrogen fuel: production, transport and storage, Gupta (CRC Press)
4. Nanomaterials for sustainable energy, Quan Li (Springer)

Reference books:

1. Energy efficiency and renewable energy through nanotechnology: Ling Zang (Springer).
2. Materials in energy conversion, harvesting and storage,Kathy Lu (Wiley)
3. Energy storage systems and components, Alfred Rufer (CRC Press)
4. Handbook of Hydrogen energy, S.A. Sherif (CRC Press)

Lecture Plan

Lecture No.	Topics to be covered
1.	Energy challenge in the 21st century
2.	Introduction of nanotechnology
3.	Synthesis methods of nanomaterials (cont.)
4.	Synthesis methods of nanomaterials
5.	Characterization methods of nanomaterials (cont.)
6.	Energy storage technologies
7.	Energy harvesting technologies
8.	Criteria for choosing the nanomaterials for energy harvesting
9.	Criteria for choosing the nanomaterials for energy storage
10.	Application of nanotechnologies in the energy value chain
11.	Renewable and non-renewable energy sources (cont.)
12.	Renewable and non-renewable energy sources
13.	Development and implementation of renewable energy technologies
14.	Examples of nanotechnology energy production
15.	Examples of nanotechnology energy storage
16.	Introduction to Photovoltaics
17.	Nanotechnology for Solar Energy Collection
18.	Nanotechnology for Solar Energy Conversion
19.	Nanotechnology for water technologies
20.	Nanotechnology for water treatment and desalination
21.	Introduction of hydrogen energy
22.	Nanomaterials used for hydrogen energy generation
23.	Methods to produce hydrogen energy
24.	Hydrogen production from fossil fuels
25.	Hydrogen production from biomass
26.	Role of nanotechnology for hydrogen energy generation
27.	Fuel cell and its type
28.	Proton exchange membrane (PEM) cell
29.	Membrane: Introduction, fabrication and its engineering
30.	Methods for separation of hydrogen
31.	Overview of energy storage methods
32.	Nanomaterials used for energy storage
33.	Solution of key challenges
34.	Type of energy storages
35.	Electrochemical (Batteries)
36.	Nanomaterials for Solid State Hydrogen Storage (cont)
37.	Nanomaterials for Solid State Hydrogen Storage (cont)
38.	Hydrogen Detection Technologies for Hydrogen Safety (Cont)
39.	Hydrogen Detection Technologies for Hydrogen Safety

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT807	**Basic LabVIEW Programming**	**3**	**2**	**0**	**2**	**0**

PREREQUISITE – None

COURSE OBJECTIVE(s)
After successfully completing this course student should be able to write LabVIEW code to simulate or analyze their own data. Students should be able to interface various lab instruments to acquire data. In addition, they will be able to design/write LabVIEW code to perform an experiment according to their requirements. It will definitely reduce the dependence on commercially available software, because many times these commercially available software does not provide the data acquisition options according to the requirements of the researchers.
COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Basic of programming language, Programming in LabVIEW Environment, Front Panel and Block Diagram, Types of Data in LabView, Controls, Indicators and Function Palettes, Wiring and Debugging the Problems to run a Programme.

(No. of lectures: 9, No. of practical: 4)

Algorithm, Structures and Loop: For Loop, While Loop, Timed Structures, Case Structures, Event Structures, Math Script and Sequence.

(No. of lectures: 4, No. of practical: 2)

Introduction and Elements of Arrays, Creating Arrays and Programming using Arrays; Clusters, Conversion of Arrays to Cluster and matrix, Conversion of Clusters and Matrix to Arrays; Strings: Properties and Creation of Strings; LabVIEW programming using Charts and Graphs. Example of inbuild Programmes.

(No. of lectures: 8, No. of practical: 4)

Simulate Signals and Analyze the input Signals, File Handling using LabVIEW Environment, Connecting Instrument with LabVIEW and Data Acquisition, Hands-on Practice: Interfacing and Data Acquisition from Various Lab Instruments.

(No. of lectures: 5, No. of practical: 3)

TEXT BOOKS / REFERENCE BOOKS:

1. Virtual instrumentation using LabVIEW: Sanjay Gupta, Joseph John (Tata McGraw-Hill)
2. LabVIEW for Everyone: Graphical Programming Made Easy and Fun: Jeffrey Travis, Jim Kring (Prentice Hall).
3. LabVIEW based Advanced Instrumentation Systems: LabVIEW based Advanced Instrumentation Systems: S. Sumathi and P. Surekha (Springer).
4. Analog Electronics with LabVIEW: Kenneth L. Ashley (Prentice Hall).

Reference Manuals:

1. LabVIEW User Manual, National Instruments (NI)

Lecture Plan

Lecture No.	Topics to be covered
1	Introduction of LabVIEW, Basics of Programming Language
2	LabVIEW Environment and Creating new VI
3	Front Panel Tools
4	Front Panel: Different types of Control and Changing input data type
5	Block Diagram and Indicators
6, 7	Functions Palette
8	Wiring and Run the Programme
9	Debugging the Problem and Help
10	Algorithm Construction, Structures: For Loop
11	Structures: While Loop
12	Timed Structures and Case Structures
13	Event structure and Math Script, Structures: Sequence
14	Array Introduction & Creating Arrays
15	Elements of the Array, Multidimensional Arrays
16	Clusters
17	Inter-conversion of Arrays and Cluster
18	Properties of the String & Creating Strings
19	Waveform Charts
20	Waveform Graphs and X-Y Graphs
21	Searching for example
22	Simulation of Signals and Analyzing the Signal
23	File Handling
24	Introduction to Data Acquisition
25, 26	Interfacing Instruments

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
24PHT808	Membrane Technology for Energy Applications	3	3	0	0	0

PREREQUISITE: Material Science.

COURSE OBJECTIVE(s): These objectives are designed to have a basic understanding of the fundamental concepts and operational principles of Membrane Technology for Energy Applications.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Types and uses of membranes; Isotropic Membranes, Anisotropic membranes, Ceramic, Metallic, and Liquid Membranes; Zeolite, Carbon, and Glass Membranes; Porous Membranes, Dense Membranes, Mixed-Matrix Membranes, Hollow-Fiber Membranes, Ion-exchange Membranes, Recent development in membranes; Solution-diffusion model, Pore-flow membranes.

(No. of lectures: 9)

Types and uses of modules: Plate and frame module, Spiral wound module, Tubular module, Capillary module, Comparison of module configurations.

(No. of lectures: 5)

Concentration polarization in liquid separation processes, Gel layer model, Osmotic pressure model, Boundary layer resistance model, Concentration polarization in gas separation processes, Membrane fouling and fouling control; Reverse Osmosis, Ultrafiltration and Microfiltration and their applications; Dialysis and Electrodialysis and their applications.

(No. of lectures: 9)

Membrane reactors and membrane bioreactors; Prevaporation and its applications; Gas separation; Membrane Contactors; Introduction of synthetic membrane, Preparation of synthetic membranes, Phase inversion membranes, Preparation technique for composite membranes.

(No. of lectures: 8)

Membrane Applications: Fuel cell, Batteries, Hydrogen production, Membranes for coal and gas power plants; Membrane Characterization Techniques: Characterization of porous membranes, Characterization of ionic membranes, Characterization of non-porous membranes.

(No. of lectures: 8)

TEXT/ REFERENCE BOOKS: -

1. Baker, R. W. (2012), Membrane Technology and Applications, 3rd Ed., Wiley, UK.
2. Mulder, M. Mulder, J. (1996), Basic Principles of Membrane Technology, Kluwer Academic.
3. W. S. W. Ho and K. K. Sirkar (1992), Membrane Handbook, Chapman & Hall, NY.
4. N.N. Li, A. G. Fane, W.S.W. Ho and T. Matsuura, (2008), Advanced Membrane Technology, Wiley.
5. M. Cheryan, (1998), Ultrafiltration and Microfiltration Handbook, CRC Press.

Lecture Plan

Lecture no.	Topics to be covered
1	Types and uses of membranes; Isotropic Membranes, Anisotropic membranes
2	Ceramic, Metallic, and Liquid Membranes; Zeolite, Carbon, and Glass Membranes; Porous Membranes
3	Ceramic, Metallic, and Liquid Membranes; Zeolite, Carbon, and Glass Membranes; Porous Membranes
4	Dense Membranes, Mixed-Matrix Membranes
5	Hollow-Fiber Membranes
6	Ion-exchange Membranes
7	Recent developments in membranes
8	Solution-diffusion model, Pore-flow membranes
9	Solution-diffusion model, Pore-flow membranes
10	Types and uses of modules: Plate and frame module
11	Types and uses of modules: Plate and frame module
12	Spiral wound module
13	Tubular module
14	Capillary module, Comparison of module configurations
15	Concentration polarization in liquid separation processes
16	Gel layer model, Osmotic pressure model
17	Boundary layer resistance model
18	Concentration polarization in gas separation processes
19	Membrane fouling and fouling control
20	Reverse Osmosis, Ultrafiltration
21	Reverse Osmosis, Ultrafiltration
22	Microfiltration and their applications
23	Dialysis and Electrodialysis and their applications
24	Membrane reactors and membrane bioreactors
25	Prevaporation and its applications
26	Gas separation; Membrane Contactors
27	Gas separation; Membrane Contactors
28	Introduction of synthetic membrane
29	Preparation of synthetic membranes
30	Phase inversion membranes
31	Preparation technique for composite membranes
32	Membrane Applications: Fuel cell, Batteries, Hydrogen production
33	Membrane Applications: Fuel cell, Batteries, Hydrogen production
34	Membrane Applications: Fuel cell, Batteries, Hydrogen production
35	Membranes for coal and gas power plants
36	Membrane Characterization Techniques
37	Characterization of porous membranes
38	Characterization of ionic membranes
39	Characterization of non-porous membranes

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT801	**Advanced Quantum Mechanics**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: None

COURSE OBJECTIVE(s)
This is an advanced level course in Quantum mechanics which objects to teach about various approximation methods in physics to calculate the approximate values of energy for various systems. Students will be able to learn the methods to find transition probability for absorption and emission. The objective is to give them ideas about laboratory and center of mass frame and study the scattering phenomena in both these frames. This course will let students appreciate the beauty of quantum mechanics in the form of the Born approximation and its validity. Students will be able to study the wave functions of system of identical particles.

COURSE OUTCOMES:

CO1	To introduce the Advanced level Quantum Mechanics for physical systems.
CO2	To introduce the Time dependent perturbation theory and scattering.
CO3	To introduce the relativistic wave equations.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Time dependent perturbation theory, first order perturbative expression for the transition amplitude and probability, harmonic perturbations, transition probability under constant perturbation, Fermi's golden rule.

(No. of lectures: 6)

Interaction of radiation with matter, spontaneous emission, absorption, induced emission, dipole transitions, selection rules, identical particles, Pauli exclusion principle.

(No. of lectures: 10)

Non-relativistic scattering, solution of scattering problem by the method of Green's function, Born approximation and its validity for scattering problems, partial wave analysis, optical theorem.

(No. of lectures: 10)

Introduction to relativistic wave equations, Klein-Gordon equation, plane wave solution of Klein-Gordon equation, Dirac equation for a free particle, Dirac matrices, Dirac spinors, covariant form of Dirac equation, plane wave solutions of Dirac equation: energy spectrum, negative energy states, spin of the Dirac particle, Dirac, Weyl and Majorana equation.

(No. of lectures: 13)

TEXT BOOKS/ REFERENCE BOOKS: -

1. L. I. Schiff, Quantum Mechanics, 3rd edition, (McGraw Hill Book Co., New York 1968).
2. E. Merzbacher, Quantum Mechanics, 3rd edition, (John Wiley & Sons, Inc1997)
3. Quantum Mechanics, Nouredine Zettili, Wiley
4. A. Ghatak & S. Lokanathan, Quantum Mechanics: Theory and Applications, 5th Edition, (Macmillan India, 2004)
5. Quantum Mechanics A Modern Approach: A. Das and A. C. Milissiones (CRC Press).
6. Quantum Mechanics: E. Merzbacher (Wiley).
7. Advanced Quantum Mechanics: J.J. Sakurai (Addison Wesley Publishing Co.)
8. Principles of Quantum Mechanics: R. Shankar.
9. Introduction to Quantum Mechanics: David J. Griffiths (Pearson Education).
10. Quantum Mechanics by Mathews and Venkatesan (McGraw Hill)
11. Quantum Mechanics by G.Arul das (PHI) Reference Books:

Lecture Plan

Lecture No.	Topics to be covered
1.	Review on Time independent Perturbation theory
2.	Introduction to Time dependent perturbation theory
3.	First order perturbative expression for the transition amplitude and
4.	Harmonic perturbations
5.	Transition probability under constant perturbation,
6.	Fermi's golden rule
7.	Interaction of radiation with matter
8.	spontaneous emission
9.	absorption
10.	Induced emission
11.	Dipole transitions
12.	Selection rules
13.	Identical particles
14.	Pauli exclusion principle
15.	Non-relativistic scattering
16.	Solution of scattering problem
17.	Solution of scattering problem by the method of Green's function
18.	Born approximation
19.	Validity of Born approximation for scattering problems
20.	Partial wave analysis
21.	Optical theorem
22.	Problem solving
23.	Problem solving
24.	Problem solving
25-26.	Review on Schrodinger time dependent wave equation
27.	Introduction to relativistic wave equations
28.	Klein-Gordon equation,
29.	plane wave solution of Klein-Gordon equation
30-31.	Dirac equation for a free particle
32.	Dirac matrices
33.	Dirac spinors
34.	Covariant form of Dirac equation
35.	Plane wave solutions of Dirac equation: energy spectrum
36.	Negative energy states
37.	Spin of the Dirac particle
38.	Maiorana equation
39.	Problem solving

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT814	**Numerical Methods and computer programming**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – basic knowledge about computer programming

COURSE OBJECTIVE(s)
To develop the mathematical skills of the students in the areas of numerical methods. To apply computer programming to solve numerical methods and to find the solution of algebraic equations using different methods under different conditions, and numerical solution of system of algebraic equations.

COURSE ASSESSMENT
The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Basics of MATLAB programming, Array operations in MATLAB, Loops and execution control, working with files: Scripts and Functions, Plotting and program output

(No. of lectures: 10)

Linear Equations: Linear algebra in MATLAB, Gauss Elimination. LU decomposition and partial pivoting, Iterative methods: Gauss Siedel, Special Matrices: Tri-diagonal matrix algorithm Nonlinear Equations: Nonlinear equations in single variable, Fixed-point iteration in single variable, Newton-Raphson in single variable, MATLAB function solve in single and multiple variables, Newton-Raphson in multiple variables

(No. of lectures: 09)

UNIT 3: Numerical Differentiation and Integration: Numerical Differentiation in single variable, Numerical differentiation: Higher derivatives, Differentiation in multiple variables Newton-Cotes integration formulae, multi-step application of Trapezoidal rule, MATLAB functions for integration

(No. of lectures: 10)

UNIT 4: Ordinary Differential Equations (ODE) Introduction to ODEs; Implicit and explicit Euler's methods, Second Order Runge-Kutta Methods, MATLAB ode45 algorithm in single variable, Higher order Runge-Kutta methods, Error analysis of Runge-Kutta method, Practical example for ODE. Solving particle in 1 D box using programming and similar problems, monte carlo simulation, projectile motion, random walk problem, Rutherford scattering

(No. of lectures: 10)

Text /Reference Books:

1. Computer Oriented Numerical Methods: V. Rajaraman (Prentice Hall of India).
2. Numerical Analysis: M. K. Jain.
3. Introduction Methods of Numerical Analysis: C.S. Sastry (PHI).
4. Numerical Analysis: E. Krishnamurthy.
5. Monte Carlo Simulation: Binder and Herman.
6. An Introduction to Computation Physics: T. Tang (Cambridge Univ. Press 1997).
7. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers by Rudra Pratap (Oxford University Press)

Lecture Plan

Lecture No.	Topics to be covered
1	Basics of MATLAB programming
2	Array operations in MATLAB
3	Loops and execution control
4	working with files: Scripts and Functions
5-6	Plotting and program output
7	Linear algebra in MATLAB, Gauss Elimination
8-9	LU decomposition and partial pivoting
10	Iterative methods: Gauss Siedel
10-11	Special Matrices: Tri-diagonal matrix algorithm
12	Nonlinear equations in single variable
13	Fixed-point iteration in single variable
14	Newton-Raphson in single variable
15-16	MATLAB function fsolve in single and multiple variables
17-18	Newton-Raphson in multiple variables
19	Numerical Differentiation in single variable
20	Numerical differentiation: Higher derivatives
21-22	Differentiation in multiple variables
23	Newton-Cotes integration formulae
24-25	multi-step application of Trapezoidal rule
26-27	MATLAB functions for integration
28-29	Introduction to ODEs; Implicit and explicit Euler's methods
30	Second Order Runge-Kutta Methods
31	MATLAB ode45 algorithm in single variable
32	Higher order Runge-Kutta methods
33-34	Error analysis of Runge-Kutta method
35	Practical example for ODE
36-37	Solving particle in 1 D box using programming and similar problems
38	monte carlo simulation, projectile motion
39	Rutherford scattering

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT716	**Materials Science and Engineering**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE – basic knowledge about solid state physics

COURSE OBJECTIVE(s)

To describe the fundamental knowledge about the materials science and engineering, the structure and related properties of individual materials, classified as metals, ceramics or polymers by free hand sketching and by calculation of specific physical and chemical properties

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Defects-types of defects, motion and properties of dislocation, diffusion in solids, Fick's laws of diffusion, solutions to Fick's second law, applications of Fick's law, atomic theory of diffusion, mechanism of diffusion, basics of microscopy, SEM and TEM, deep level transient spectroscopy (DLTS)

(No. of lectures: 9)

Phase transformations in solids- solid solutions, phase rule, binary phase diagrams, binary isomorphous systems, binary eutectic systems, types of transformations, homogeneous and heterogeneous transformation, thermodynamics of transformation, nucleation and growth kinetics, overall kinetics, recovery, recrystallization and grain growth.

(No. of Lectures: 15)

Properties of materials- mechanical properties of materials-elastic and plastic deformation, hardness, dislocations and strengthening mechanisms, failure-fatigue and creep, corrosion and degradation of materials- corrosion rates, forms of corrosion

(No. of Lectures: 15)

Text Books:

1. Materials Science and Engineering, An Introduction by W.D.Callister, Wiley Publications.
2. Materials Science and Engineering by V.Raghvan, PHI
3. Solid State Phase Transformations by V.Raghvan, PHI
4. Essential Materials- Science and Engineering by Askeland and Phule, CENGAGE Learning
5. Basics of Materials Science and Engineering by W F Smith, Mc Graw Hill

<u>Lecture Plan</u>

Lecture No.	Topics to be covered
1	Defects-types of defects
2-3	motion and properties of dislocation
4-5	diffusion in solids
6	Fick's laws of diffusion
7-8	solutions to Fick's second law
9	atomic theory of diffusion, mechanism of diffusion
10	Phase transformations in solids- solid solutions
11-12	binary phase diagrams
13	binary isomorphous systems
14	binary eutectic systems
15-16	types of transformations
17-19	homogeneous and heterogeneous transformation
20	thermodynamics of transformation,
21-22	nucleation and growth kinetics
23	overall kinetics, recovery
24	recrystallization and grain growth
25	Properties of materials
26-27	mechanical properties of materials
28-29	elastic and plastic deformation
30	hardness
31-32	dislocations and strengthening mechanisms
33-34	failure-fatigue and creep
34-37	corrosion and degradation of materials
38	corrosion rates
39	forms of corrosion

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

Programme: M.Sc. Physics

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
21PHT821	**Surface Physics**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE - None

COURSE OBJECTIVE(s)

The aim of this course is to give a comprehensive introduction of solid surfaces and interfaces and physics and chemistry on an atomic length scale. After successfully completing this course student should be able to understand the fundamental importance of surfaces, and how their structures and properties differ from that of bulk materials. They should be able to understand the results of surface science techniques such as XPS, AES, RBS, STM etc.

COURSE ASSESSMENT

The Course Assessment (culminating to the final grade), will be made up of the following three components;

S. No.	Component	Weightage
a)	Internal assessment (based upon assignments, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Physics of Surfaces

Physics of Surfaces: What is a surface? Surfaces and Interfaces and their importance, Surface Thermodynamics, From Solid to Surface, Morphology and Structure of Surfaces, Interfaces and Thin films, Surface geometry: truncated bulk, relaxation, reconstruction, defects and super-structures, Surface Defects, Surface Creation; Surface cleaning

(No. of lectures: 14)

Adsorption, Desorption, Chemical Reactions & Nucleation: Chemisorption, Physisorption, Adsorption, Desorption, Mechanisms of Adsorption/Diffusion/Desorption, Thermodynamics and kinetics of thin film growth, Surface Reactions: Catalysis, Crystal Growth, Chemical Reactions & Nucleation, Homogeneous and Heterogeneous nucleation kinetics, Thin Film Deposition techniques

(No. of lectures: 9)

Vacuum Technology for Applied Surface Science: Ultra High Vacuum (UHV), Basic Principles of UHV, Why UHV is required? How to attain UHV ?, UHV Setups, Vacuum Pumps, Vacuum Gauges, Surfaces in UHV, Sample preparation in UHV, Vacuum Gauges

(No. of lectures: 5)

Surfaces characterization Techniques: Auger Electron Spectroscopy (AES): Principle, Instrumentation, Chemical Analysis, X-ray Photoelectron Spectroscopy (XPS): Basics of XPS, Instrumentation, Vacuum Systems, X-ray Sources, Analyzer, Chemical Analysis, Depth Profiling, Secondary Ion Mass spectroscopy (basics, instrumentation, depth profiling, Surface structure determination by electron diffraction: LEED, RHEED, Scanning Tunneling Microscopy

(No. of lectures: 11)

Recommended Readings

Text books –
1. Surface Science- An Introduction, K Oura (Springer).
2. Physics at Surfaces, Andrew Zangwill (Cambridge University Press).
3. Surface Analysis: The Principal Techniques, John C. Vickerman, Ian S. Gilmore (Wiley).
4. Solid Surfaces, Interfaces and Thin Films, Hans Luth (Springer).

Reference books –
1. Lecture Notes on Surface Science, Philip Hofmann.
2. Physics of Surfaces and Interfaces, Haralad Ibach (Springer).

Lecture Plan

Lecture No.	Topics to be covered
1.	What is a surface?
2.	Surfaces and Interfaces and their importance
3.	Thermodynamics at the bulk and surface
4.	Gibbs adsorption equation
5.	Anisotropy of Surface Tension
6.	TSK model for surface energy
7.	Lattice & reciprocal lattice on surface, Woods terminology
8.	Relaxation at the surface
9.	Basics of Scanning Tunneling Microscopy
10.	Reconstruction at the surfaces of metals
11.	Reconstruction at the Si and Ge surface
12.	Surface creation, surface cleaning
13.	Surface point defects (Adatoms, vacancies, kinks, step adatoms etc.)
14.	Surface line defects (Edge dislocations, Screw dislocations etc.)
15.	Adsorption (Physisorption)
16.	Adsorption (Chemisorption, ex. O_2 and CO)
17.	Adsorption Kinetics
18.	Thermal and Non-Thermal Desorption
19.	Fundamentals of thin film and thin film growth
20.	Homogeneous Nucleation,
21.	Diffusion and surface controlled growth
22.	Heterogeneous Nucleation kinetics
23.	Thin Film Deposition techniques (physical and chemical)
24.	Ultra High Vacuum for surface science
25.	Vacuum concepts
26.	UHV Setups, Vacuum Pumps (rotary vane, diaphragm)
27.	Vacuum Pumps (turbomolecular, ion pump, Ti sublimation etc.)
28.	Vacuum Gauges (Thermocouple, Pirani Gauges, Ionization Gauges etc.)
29.	Basics of electron spectroscopy
30.	Electron Energy Analyzers
31.	Auger Electron Spectroscopy (AES): Principle of AES
32.	AES: Instrumentation, Chemical Analysis, depth profiling etc.
33.	X-ray Photoelectron Spectroscopy (XPS), Basics physics of XPS
34.	XPS: Instrumentation, Chemical Analysis
35.	XPS Analysis, quantification, charging effects etc.
36.	Secondary Ion Mass spectroscopy (SIMS), Basics of SIMS,
37.	Instrumentation and depth profiling of SIMS
38.	Surface structure determination by LEED
39.	Surface structure determination by RHEED