MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT101	Waves and Optics	4	3	1	0	0

COURSE CONTENTS

Free oscillations:- Simple harmonic oscillations differential equation of SHM and its solution, amplitude, frequency, time period and phase, velocity and acceleration, kinetic, potential and total energy and their time average values, free oscillation of systems with one degree of freedom: mass-spring system, simple pendulum and compound pendulum, superposition of harmonic oscillations: superposition of two collinear harmonic oscillations, linearity and superposition principle, oscillations having equal frequencies and oscillations having different frequencies (beats), superposition of n collinear harmonic oscillations with equal phase differences and equal frequency differences, superposition of two mutually perpendicular simple harmonic motions, graphical and analytical methods, Lissajous figures and their uses **(No. of lectures- 10)**

Damped and forced oscillations: - Differential equation for damped harmonic oscillator and its solution, under-damping, over-damping and critical-damping, energy of an under-damped harmonic oscillator, quality factor of an under-damped harmonic oscillator, forced oscillations of an undamped and damped harmonic oscillator, transient and steady state behavior, resonance, sharpness of resonance, resonance in a lightly damped system and quality factor of forced damped oscillator **(No. of lectures- 5)**

Waves Motion: - Plane and spherical waves. longitudinal and transverse waves. plane progressive (traveling) waves. wave equation in differential form. particle and wave velocities. pressure of a longitudinal wave. energy transport. intensity of wave. Water waves: ripple and gravity waves.
(No. of lectures 5)

Superposition of Harmonic waves: - Velocity of transverse vibrations of stretched strings, standing (stationary) waves in a string: fixed and free ends. analytical treatment. changes with respect to position and time. energy of vibrating string. transfer of energy. normal modes of stretched strings. plucked and struck strings. superposition of n harmonic waves, phase velocity and group velocity.
(No. of lectures 8)

Wave Optics: -Huygens' Principle and its applications, Interference: Young's double slit experiment. Interference in Thin Films: parallel and wedge shaped films. Newton's Rings: Measurement of wavelength. Multiple beam interferometry, Fabry-Perot interferometer. temporal and spatial Coherence, Fraunhofer diffraction: single slit. circular aperture, resolving power of a telescope. double slit. multiple slits. diffraction grating. resolving power of grating Rayleigh criterion for resolution. **(No. of lectures 11)**

TEXT BOOKS/ REFERENCE BOOKS: -

1. Vibrations and Waves, A. P. French, CRC Press
2. Berkeley Physics Course Volume 3: Waves, Frank S. Crawford, McGraw Hill Education.
3. The Physics of Waves and Oscillations, N. K. Bajaj, McGraw Hill Education
4. Fundamentals of Waves & Oscillations, K. Uno Ingard, Cambridge University Press
5. An Introduction to Mechanics, Daniel Kleppner, Robert J. Kolenkow, McGraw Hill Education
6. Optics, Eugene Hecht and A. R. Ganesan, Pearson Education limited,
7. Optics, Ajoy Ghatak, McGraw Hill education.
8. Fundamentals of Optics, Francis A. Jenkins and Harvey E. White. McGraw Hill Education.

Lecture Plan

Lecture No.	Topics to be covered
1	Simple Harmonic Oscillations. Differential Equation of SHM and its Solution. Amplitude, Frequency, Time Period and Phase
2	Velocity and Acceleration. Kinetic, Potential and Total Energy and their Time Average Values
3	Free oscillation of systems with one degree of freedom: Mass-spring system, simple pendulum
4	Compound pendulum
5	Superposition of harmonic oscillations: Superposition of Two Collinear Harmonic Oscillations
6	Linearity and Superposition Principle. Oscillations having Equal Frequencies and oscillations having different frequencies (Beats).
7	Superposition of N Collinear Harmonic Oscillations with equal phase differences and equal frequency differences
8	Superposition of two mutually perpendicular simple harmonic motions
9	Graphical and analytical methods
10	Lissajous figures and their uses
11	Differential equation for damped harmonic oscillator and its solution
12	Under-damping, over-damping and critical-damping
13	Energy of an under-damped harmonic oscillator, Quality factor of an under-damped harmonic oscillator
14	Forced oscillations of an undamped and damped harmonic oscillator, transient and steady state behavior, Resonance
15	Sharpness of resonance, Resonance in a lightly damped system and quality factor of forced damped oscillator.
16	Plane and Spherical Waves. Longitudinal and Transverse Waves
17	Plane Progressive (Traveling) Waves
18	Wave Equation in differential form, particle and wave velocities
19	Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave
20	Water Waves: Ripple and Gravity Waves.

21	Velocity of Transverse Vibrations of Stretched Strings
22	Standing (Stationary) Waves in a String: Fixed and Free Ends
23	Analytical Treatment
24	Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy
25	Normal Modes of Stretched Strings.
26	Plucked and Struck Strings
27	Superposition of N Harmonic Waves
28	Phase velocity and Group velocity.
29	Huygens' Principle and its applications
30	Interference: Young's double slit experiment
31	Interference in Thin Films: parallel and wedge shaped films
32	Newton's Rings: Measurement of wavelength
33	Multiple beam interferometry, Fabry-Perot interferometer
34	Temporal and Spatial Coherence
35	Temporal and Spatial Coherence (continued)
36	Fraunhofer diffraction: Single slit. Circular aperture
37	Resolving Power of a telescope, double slit. Multiple slits
38	Double slit. Multiple slits (continues), Diffraction grating
39	Resolving power of grating. Rayleigh criterion for resolution.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT102	Mechanics and Relativity	4	3	1	0	0

COURSE CONTENTS

Kinematics and dynamics- Polar coordinates. velocity and acceleration in polar coordinates, inertial frames, review of newton's laws of motion and their applications, friction, constrained motion and pseudo forces, dynamics of system of particles, conservation of momentum, center of mass, momentum of variable mass system: motion of rocket. work energy theorem, kinetic energy, conservative and non-conservative forces, potential energy, law of conservation of energy, work done by a non-conservative force. elastic and inelastic collisions, center of mass and laboratory frames. Lagrangian and Hamiltonian formalism: generalized coordinates, configuration space, action principle, Lagrange's equation from action principle, Legendre transformations, phase space, Hamilton's equation. **(No. of lectures- 13)**

Central force problem and gravitation – Motion of particle under central force field, two body problem and its reduction to one body problem and its solution, equivalent one-dimensional problem and ideas of orbits, differential equation for orbits and its solution for Kepler's problem. Law of gravitation, Poisson equation, gravitational potential due to spherical shell and solid sphere **(No. of lectures- 6)**

Rotational motion- Angular momentum and torqu**e,** conservation of angular momentum for a system of particles, rotation about a fixed axis, moment of inertia, calculation of moment of inertia for rectangular, cylindrical and spherical bodies, theorem of parallel and perpendicular axis, dynamics of fixed axis rotation: relation between torque and angular acceleration, kinetic energy of rotation, motion involving translation and rotation, general rigid body motion, gyroscope, moment of inertia tensor and principal axes, Euler equation **(No. of lectures- 8)**

Fluid Mechanics- Definition of a fluid, density and pressure of a fluid, hydrostatic equilibrium, pressure distribution in an acceleration fluid, fluid dynamics: velocity field of a fluid, pressure force on a fluid element, Eulerian and Lgrangian description, flow pattern: streamlines, streak lines, path lines and timelines, control volume, volume and mass rate of flow, equation of continuity, acceleration of a fluid, Euler equation, Bernoulli's equation, viscosity, Navier-stokes' equation **(No. of lectures- 6)**

Special theory of relativity: Michelson-Morley experiment**,** postulates of special theory of relativity, inertial frames, Galilean transformation, simultaneity and order of events, Lorentz transformation, time dilation and length contraction, proper time and proper length relativistic addition of velocities, relativistic momentum and relativistic energy, collisions and conservation of energy and momentum in special relativity. **(No. of lectures- 6)**

TEXT BOOKS/ REFERENCE BOOKS: -

1. An Introduction to Mechanics, Daniel Kleppner and Robert Kolenkow (McGraw Hill Education)
2. Berkeley Physics Course Volume 1: Mechanics, Charles Kittel, Walter Knight, Malvin Ruderman, Carl Helmholz and Burton Moyer (McGraw Hill Education)
3. Mechanics, D. S. Mathur (S. Chand & Company limited)
4. Classical Mechanics –Goldstein, Poole and Safko (Pearson Education)
5. Introduction to Classical Mechanics with Problems and Solutions: David Morin (Cambridge University Press)
6. Mechanics, Keith R. Symon (Addison-Wesley Publishing Company)
7. Fluid Mechanics, Frank M. White and Henry Xue (McGraw Hill Education)
8. Concepts of Modern Physics, Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury (McGraw Hill Education)

Lecture Plan

Lecture No.	Topics to be covered
1	Polar coordinates. Velocity and acceleration in polar coordinates
2	Review of Newton's laws of motion and their applications, Friction
3	Constrained motion and Pseudo forces, Dynamics of system of particles
4	Conservation of momentum, Center of mass,
5	Momentum of variable mass system: Motion of rocket.
6	Work energy theorem, Kinetic energy, Conservative and Non-conservative forces
7	Potential energy, Law of conservation of energy, Work done by a non-conservative force
8	Elastic and inelastic collisions, Center of mass and laboratory frames
9	Generalized coordinates, configuration space,
10	Action principle
11	Lagrange's equation from action principle
12	Legendre transformations,
13	Legendre transformations, phase space, Hamilton's equation.
14	Motion of particle under central force field,
15	Two body problem and its reduction to one body problem and its solution
16	Equivalent one-dimensional problem and ideas of orbits
17	Differential equation for orbits and its solution for Kepler's problem
18	Law of gravitation, Poisson equation
19	Gravitational potential due to spherical shell and solid sphere
20	Angular momentum and torque,
21	Conservation of angular momentum for a system of particles
22	Rotation about a fixed axis, Moment of inertia
23	Calculation of moment of inertia for rectangular, cylindrical and spherical bodies
24	Theorem of parallel and perpendicular axis,
25	Dynamics of fixed axis rotation: relation between torque and angular acceleration
26	Kinetic energy of rotation, Motion involving translation and rotation, General rigid body motion
27	Gyroscope, Moment of inertia tensor and principal axes, Euler equation

28	Definition of a fluid, Density and pressure of a fluid, hydrostatic equilibrium
29	Pressure distribution in an acceleration fluid
30	Fluid dynamics: velocity field of a fluid, Pressure force on a fluid element, Eulerian and Lgrangian description
31	Flow pattern: streamlines, streaklines, pathlines and timelines, Control volume, Volume and mass rate of flow
32	Equation of continuity, Acceleration of a fluid, Euler equation
33	Bernoulli's equation, Viscosity, Navier-Stokes' equation
34	Michelson-Morley experiment
35	Postulates of special theory of relativity, Inertial frames, Galilean transformation
36	Simultaneity and order of events, Lorentz transformation
37	Time dilation and length contraction, Proper time and proper length Relativistic addition of velocities
38	Relativistic momentum and relativistic energy
39	Collisions and conservation of energy and momentum in special relativity

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT201	Introduction to Thermodynamics	4	3	1	0	0

PREREQUISITE None

COURSE OBJECTIVE(s)

This course provides an introduction to the most powerful engineering principles -Thermodynamics: the science of energy and its transformation from one form to another form. The subject is widely applicable in several branches of engineering and science.

The objective of this course is to introduce systematic different tools needed to analyze energy systems from various daily lives to large scale engineering applications.

COURSE OUTCOMES:

CO1	To impart fundamental Physics knowledge to engineering UG students, primarily in the areas of Thermodynamics and Kinetic theory of gases.
CO2	To science of energy and its transformation from one form to another form.
CO3	To introduce systematic different tools needed to analyze energy systems from various daily lives to large scale engineering 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

Concept of ideal or perfect gas, Maxwell-Boltzmann Law of distribution of velocities in an ideal gas, mean, RMS and most probable speeds, degrees of freedom, law of equipartition of energy, specific heats of Gases. **(No. of lectures- 5)**

Behavior of real gases, deviations from the ideal gas equation, the virial equation, critical Constants, continuity of state, Boyle temperature, Van der Waal's Equation of State for real gases, law of corresponding States. P-V Diagrams, Joule's experiment, free adiabatic expansion of a perfect Gas, Joule-Thomson porous plug experiment, Joule-Thomson cooling. **(No. of lectures- 9)**

Thermodynamic system, Zeroth and first law of thermodynamics, thermo dynamical equilibrium, concept of heat, work and heat energy, state functions, internal energy, specific heat of a gas (v and t independent), isochoric process, isobaric process, adiabatic process, adiabatic equation of a perfect gas, cyclic process, non-isolated system(internal energy of the universe), isothermal process, work done during isothermal and adiabatic processes, heat engines, Carnot's cycle, Carnot's theorem, second law of thermodynamics.
(No. of lectures- 9)

Concept of entropy, change of entropy, change of entropy in adiabatic process, change of entropy in reversible cycle, principle of increase of entropy, change of entropy in irreversible process, the temperature-entropy diagrams, physical significance of entropy, entropy of a perfect gas, entropy of a steam, third law of thermodynamics **(No. of lectures- 6)**

Thermodynamic variables, Maxwell's thermo dynamical relations, applications of Maxwell's thermodynamic relations, specific heat equation, Joule-Thomson cooling, Joule Thomson coefficient for perfect gas and Vander waals gas, Clausius - Clapeyron's equation (first latent heat equation), Clapeyron's latent heat equation using Maxwell's thermodynamic relations, Clapeyron's latent heat equation using Carnot's cycle, thermodynamic relations thermodynamic potentials, significance of thermodynamic potentials, relation of thermodynamic potentials with their variables, entropy and the second law of thermodynamics, first order and second order phase transitions, emf of a reversible cell (Gibbs Helmholtz equation) **(No. of lectures- 10)**

TEXT BOOKS/ REFERENCE BOOKS: -

1. Thermodynamics by Enrico Fermi (Courier Dover Publications, 1956)
2. A Treatise on Heat: Including Kinetic Theory of Gases, Thermodynamics and Recent Advances in Statistical Thermodynamics by Meghnad Saha, B. N. Srivastava (Indian Press, 1958)
3. Heat and Thermodynamics: An Intermediate Textbook by Mark Waldo Zemansky, Richard Dittman (McGraw-Hill, 1981
4. Thermal Physics by Garg, Bansal and Ghosh (Tata McGraw-Hill, 1993)
5. Heat Thermodynamics and Statistical Physics by Brij Lal, N. Subrahmanyam, P.S. Hemne (S. Chand & Company LTD.)
6. Chemical Engineering Thermodynamics by Y.V.C.Rao (University Press)
7. Thermodynamics and Kinetic theory of Gases by W.Pauli (Dover Publications)
8. Thermal Physics by Kittle and Kromer (W.H.Freeman & Co Ltd)
9. Concepts in thermal physics by S.J. Blundell and K.Blundell (Oxford)

Lecture Plan

Lecture No.	Topics to be covered
1	Concept of Ideal or Perfect Gas
2	Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas
3	Mean, RMS and Most Probable Speeds, Degrees of Freedom
4	Law of Equipartition of Energy
5	Specific Heats of Gases
6	Behavior of Real Gases, Deviations from the Ideal Gas Equation
7	The Virial Equation, Critical Constants
8	Continuity of State, Boyle Temperature

9	Van der Waal's Equation of State for Real Gases, Law of corresponding states
10	P-V Diagrams, Joule's Experiment
11	Free Adiabatic Expansion of a Perfect Gas and Joule-Thomson Cooling
12	Thermodynamic system, Zeroth and First Law of Thermodynamics
13	Thermo dynamical Equilibrium, Concept of Heat, Work and heat energy
14	State Functions, Internal Energy
15	Specific heat of a Gas (V and T independent)
16	Isochoric process, Isobaric process
17	Adiabatic process, Adiabatic equation of a perfect gas
18	Cyclic process, non-isolated system (internal energy of the universe)
19	Isothermal process, Work Done during Isothermal and adiabatic processes
20	Heat Engines, Carnot's Cycle
21	Carnot's Theorem
22	Second Law of Thermodynamics.
23	Concept of Entropy, Change of Entropy, temperature-entropy diagrams
24	Change of entropy in adiabatic process
25	Change of Entropy in reversible cycle
26	Principle of Increase of Entropy, Change of entropy in irreversible process
27	Physical Significance of entropy, Entropy of a Perfect Gas
28	Entropy of a steam, Third Law of Thermodynamics.
29	Thermodynamic variables, Maxwell's Thermo dynamical relations
30	Applications of Maxwell's Thermodynamic relations, specific heat equation
31	Joule-Thomson cooling
32	Joule Thomson coefficient for perfect gas and Vander Waals gas
33	Clausius-Clapeyron's equation (First Latent heat equation)
34	Clapeyron's Latent heat equation using Maxwell's thermodynamic relations, Clapeyron's Latent heat equation using Carnot's cycle,
35	Thermodynamic relations, Thermodynamic potentials
36	Significance of thermodynamic potentials, Relation of thermodynamic potentials with their variables
37	Entropy and the second law of thermodynamics
38	First order and second order phase transitions
39	EMF of a Reversible cell (Gibbs Helmholtz equation)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT301	Mathematical Methods in Physics – I	**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, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Linear Algebra - Vector spaces, linear transformations, matrices, functions of matrices, eigenvalues and eigenvectors, normal matrices, spectral theorem, Gram-Schmidt orthogonalization process, generalization to differential operators, applications towards quantum mechanics, Dirac's notation

(No. of lectures- 10)

Vector Calculus - Coordinate systems (cartesian, polar, spherical), Review of concepts seen in previous courses (gradient, divergence, curl, second order vector differential operators), path and surface integrals, Gauss and Stokes theorems **(No. of lectures- 5)**

Complex Analysis - Analytic functions and Cauchy-Riemann conditions, Cauchy's integral formula, Laurent series, singularities, residues, evaluation of real and complex integrals, Laplace's method for approximate evaluation of integrals, asymptotic series, Stirling's series

(No. of lectures- 12)

Ordinary Differential Equations - General solution of 1st and 2nd order linear ODEs, singular points, series solution to ODEs (Frobenius method), special functions (Bessel, Hermite, Laguerre, Legendre)

(No. of lectures- 12)

TEXT / REFERENCE BOOKS

1. A Guided Tour of Mathematical Physics (Third Edition), Roel Snieder and Kasper van Wijk (Cambridge University Press)
2. A Course in Mathematics for Students of Physics Vol. 1, Paul Bamberg and Shlomo Sternberg (Cambridge University Press)
3. Mathematical Methods for Physicists: A Concise Introduction, Tai L. Chow (Cambridge University Press)
4. Mathematics for Physics, Michael Stone and Paul Goldbart (Cambridge University Press)
5. Mathematical Methods for Physicists (Seventh Edition), George B. Arfken, Hans J. Weber, Frank E. Harris (Academic Press)
6. Mathematical Physics - The Basics, S. D. Joglekar (University Press) 2005
7. Mathematical Physics: Advanced Topics, S. D. Joglekar (University Press) 2006

Lecture Plan

Lecture No.	Topics to be covered
	Unit 1: Vector Calculus
1	Abstract vector spaces, linear transformations
2	Recap of matrices from earlier courses, standard properties and theorems
3	Functions of matrices
4	Eigenvalues and eigenvectors
5	Normal matrices, spectral theorem
6	Gram-Schmidt orthogonalization algorithm
7	Infinite dimensional vector spaces – functions as vectors
8	Infinite dimensional vector spaces – differential operators
9	Infinite dimensional vector spaces – applications in Quantum Mechanics
10	Infinite dimensional vector spaces – practice problems
11	Polar and spherical coordinates
12	Gradient, Curl and Divergence
13	Path and surface integrals of functions of vector arguments
14	Gauss' Theorem
15	Stokes' Theorem
16	Analytic functions, Cauchy-Reimann conditions
17	Derivatives and integrals in complex plane
18	Cauchy's integral theorem
19	Cauchy's integral formula
20	Singularities and their classification
21	Laurent series
22	Residue theorem
23	Evaluation of integrals using residue theorem – some examples
24	Laplace's method for approximate evaluation of integrals
25	Laplace's method for approximate evaluation of integrals II

26	Asymptotic series
27	Stirling’s series – properties and derivation
28	First order ODEs and general solution
29	Second order homogeneous ODEs with constant coefficients
30	Second order inhomogeneous ODEs with constant coefficients
31	Sturm-Liouville Theory
32	Sturm-Liouville Theory contd. - connection with vector spaces
33	Singular points and their classification
34	Series solution to ODEs (Frobenius’ method)
35	Series solution to ODEs (Frobenius’ method) contd.
36	Bessel functions
37	Hermite polynomials
38	Legendre polynomials
39	Laguerre polynomials

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT302	Computational Physics	4	2	1	2	0

PREREQUISITE – Quantum Mechanics, Condensed Matter Physics

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
d)	Internal assessment (based upon assignments, quizzes and attendance)	20%
e)	Mid-term examination	30%
f)	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 **(No. of lectures- 9)**

Numerical Differentiation and Integration - Numerical Differentiation in single variable, Numerical differentiation: Higher derivatives, Differentiation in multiple variables, multi-step application of Trapezoidal rule, MATLAB functions for integration **(No. of lectures- 10)**

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 **(No. of lectures- 10)**

TEXT BOOKS/ REFERENCE BOOKS: -

1. Computer Oriented Numerical Methods: V. Rajaraman (Prentice Hall of India)
2. Numerical Analysis: M. K. Jain (New Age International Publishers)
3. Introduction Methods of Numerical Analysis: C.S. Sastry (Prentice Hall of India)
4. Monte Carlo Simulation in Statistical Physics, Kurt Binder, Dieter W. Heermann (Springer-Verlag Berlin and Heidelberg)
5. 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
12-13	Nonlinear equations in single variable
14	Fixed-point iteration in single variable
15-16	Newton-Raphson in single variable
17-18	Numerical Differentiation in single variable
19-20	Numerical differentiation: Higher derivatives
21-22	Differentiation in multiple variables
23-24	Newton-Cotes integration formulae
25-26	multi-step application of Trapezoidal rule
27-28	MATLAB functions for integration
29-30	Introduction to ODEs; Implicit and explicit Euler's methods
31-32	Second Order Runge-Kutta Methods
33-35	MATLAB ode45 algorithm in single variable
36-37	Higher order Runge-Kutta methods
38-39	Error analysis of Runge-Kutta method

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT303	Electromagnetic Theory	4	3	1	0	0

PREREQUISITE
None

COURSE OBJECTIVE(s)
This course aims to gain a deep understanding of the fundamental principles governing electrostatics, magnetostatics, and electrodynamics. Also, students learn how to develop problem-solving skills to analyze and solve complex problems in various practical scenarios, including applications in engineering, physics, and other fields.

COURSE OUTCOMES:

CO1	To understand the fundamental laws governing electric and magnetic fields.
CO2	Apply mathematical tools to analyze and solve electrodynamics problems.
CO3	Apply the knowledge of electrostatics, magnetostatics, and electrodynamics to real-world engineering applications.

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

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

COURSE CONTENTS

Overview of Electrostatics, Poisson and Laplace’s equations, Boundary conditions and Uniqueness theorems, Electrostatic boundary value problems, Method of images, Multipole expansion, Approximate potentials at large distances, Electric field of a dipole, Polarization, field of a polarized object, Bound charges and its physical interpretation, Gauss’s law in dielectrics and boundary conditions, Susceptibility, Permittivity, Applications of dielectric materials in capacitor

(No. of lectures- 13)

Overview of Magnetostatics, Magnetization, Effect of a Magnetic Field on Atomic Orbits, Field of a Magnetized Object, Bound currents, Physical Interpretation of Bound Currents, Magnetic Field Inside Matter, Ampère's Law in Magnetized Materials, Magnetic Susceptibility and Permeability, Magnetic levitation.

(No. of lectures- 08)

Electromagnetic wave equation, Electromagnetic waves in vacuum, Energy and Momentum in Electromagnetic Waves, Electromagnetic waves in matter, Reflection and Transmission at normal and oblique incidence, Electromagnetic waves in conductors, Frequency dependence of permittivity, Wave guides, TE modes in a Rectangular Wave Guide, Optical fibers.

(No. of lectures- 08)

Scalar and vector potentials, Potential formulation of Maxwell's equations, Gauge transformations, Coulomb and Lorentz gauges, Retarded potentials, Dipole radiation, Electric dipole radiation, magnetic dipole radiation, Power radiated by a point charge, Introduction to antenna

(No. of lectures- 10)

TEXT BOOKS/ REFERENCE 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)
5. The Classical Theory of Fields: L.D. Landau, E.M. Lifshitz (Pergamon Press, Oxford).
6. Foundations of Electromagnetic Theory: J. Reitz and F.J. Milford (Addison-Wesley).
7. Electromagnetic Waves and Radiating Systems: E.C. Jordan (Prentice Hall of India).

Lecture Plan

Lecture No.	Topics to be covered
1	Overview of Electrostatics
2	Poisson and Laplace's equations
3	Boundary Conditions and Uniqueness theorems
4	Electrostatic boundary value problems
5	Method of images
6	Multipole expansion
7	Approximate potentials at large distances
8	Electric field of a dipole
9	Polarization, field of a polarized object
10	Bound charges and its physical interpretation
11	Gauss's law in dielectrics and boundary conditions
12	Susceptibility, Permittivity
13	Applications of dielectric materials in capacitor
14	Overview of Magneto-statics
15	Magnetization, Effect of a Magnetic Field on Atomic Orbits
16	Field of a Magnetized Object
17	Bound currents, Physical Interpretation of Bound Currents
18	Magnetic Field Inside Matter
19	Ampère's Law in Magnetized Materials
20	Magnetic Susceptibility and Permeability
21	Magnetic levitation
22	Electromagnetic wave equation
23	Electromagnetic waves in vacuum
24	Energy and Momentum in Electromagnetic Waves
25	Electromagnetic waves in matter
26	Reflection and Transmission at normal and oblique incidence
27	Electromagnetic waves in conductors
28	Frequency dependence of permittivity
29	Wave guides, TE modes in a Rectangular Wave Guide
30	Optical fiber
31	Scalar and vector potentials
32	Potential formulation of Maxwell's equations
33	Gauge transformations, Coulomb and Lorentz gauges
34	Retarded potentials
35	Dipole radiation, electric dipole radiation
36	Magnetic dipole radiation
37-38	Power radiated by a point charge
39	Introduction to antenna

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT304	Quantum Mechanics	4	3	1	0	0

PREREQUISITE COURSES
None

COURSE OBJECTIVES
Students will learn basic principles of Quantum Mechanics, and learn to study quantum mechanical systems

COURSE ASSESSMENT

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 - Inner product spaces and generalization to functions, operators, failures of classical physics, postulates of Quantum Mechanics, measurement process, uncertainty relations, Ehrenfest theorem and classical correspondence, continuity equation for probability **(No. of lectures-9)**

Simple one-dimensional quantum mechanical systems - Free particles, delta potential well, recap of particle in a box, scattering by a step barrier, harmonic oscillator using both Hermite polynomials and Dirac's method, Double well potential **(No. of lectures - 12)**

More complicated systems - Angular momentum eigenvalues and eigenstates, angular momentum in position basis, hydrogen atom, basic overview of spin and statistics potential
(No. of lectures - 11)

Approximate methods - Variational method, time-independent non-degenerate perturbation theory potential **(No. of lectures - 7)**

TEXT / REFERENCE BOOKS

1. Principles of Quantum Mechanics (Second Edition), R. Shankar (Springer)
2. Introduction to Quantum Mechanics (Second Edition), D. J. Griffiths (Cambridge India)
3. Quantum Mechanics (Fourth Edition), Leonard Schiff (McGraw Hill Education)
4. Quantum Mechanics (Third Edition), Eugen Merzbacher (John Wiley & Sons)

Lecture Plan

Lecture No.	Topics to be covered
1.	Inner product spaces and generalization to functions
2.	Operators
3.	Operators contd.
4.	Failures of classical physics
5.	Postulates of Quantum Mechanics
6.	Postulates of Quantum Mechanics contd. - measurement process
7.	Uncertainty relations
8.	Ehrenfest theorem and classical correspondence
9.	Continuity equation for probability
10.	Free particles
11.	Free particles contd.
12.	Delta potential well
13.	Delta potential well contd.
14.	Recap of particle in a box
15.	Scattering by an infinite step barrier
16.	Scattering by an infinite step barrier contd. – interpretation of results
17.	Scattering by a finite step barrier
18.	Harmonic oscillator in energy basis (Dirac's method)
19.	Harmonic oscillator in position basis (Hermite polynomials)
20.	Harmonic oscillator – further discussion
21.	Outlook
22.	Angular momentum in one direction only
23.	Angular momentum – general properties
24.	Angular momentum – eigenstates and eigenvalues
25.	Angular momentum in position basis
26.	Angular momentum in position basis contd.
27.	Hydrogen atom – setting up the problem
28.	Hydrogen atom – energy states
29.	Hydrogen atom – further discussion
30.	Basic overview of spin and statistics, symmetric and anti-symmetric states
31.	Energy-time uncertainty relation
32.	Outlook
33.	Variational Method
34.	Variational Method – more examples
35.	Perturbation theory (time independent, non-degenerate) – setting up
36.	Perturbation theory (time independent, non-degenerate) - derivation
37.	Perturbation theory (time independent, non-degenerate) - examples
38.	Perturbation theory (time independent, non-degenerate) – more examples
39.	Outlook

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT305	Analog Electronics	4	3	1	0	0

PREREQUISITE – ECT101: Basic Electronics Engineering

COURSE OUTCOME (s)

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

CO1	Understand the basics of BJT and operational amplifier circuits.
CO2	Design and analyse analog circuits for given specifications.
CO3	Compare design issues, advantages, disadvantages and limitations of analog circuits.
CO4	Implementation of knowledge for analog 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
j)	Internal assessment (based upon assignments, quizzes and attendance)	20%
k)	Mid-term examination	30%
l)	End Semester Examination	50%

COURSE CONTENTS

Junction Transistors - Graphical analysis of the transistor operating in CE configuration, two-port devices and hybrid model, determination of hybrid parameters (*h*) from transistor characteristics, conversion of *h*-parameters of three transistor modes, emitter follower, analysis of transistors amplifier circuit using *h*-parameters, approximate expressions, high frequency effects in transistor.

(No. of lectures- 9)

Transistor Amplifiers - Classification of amplifiers, frequency response of RC-coupled transistor amplifier, power amplifiers: Class A, B, C; amplifier Characteristics. **(No. of lectures- 7)**

Feedback in Amplifiers - Transfer gain of feedback amplifiers, basic feedback topologies and their properties: voltage-series, voltage-shunt, current-series, current-shunt; effect of negative feedback.
(No. of lectures- 5)

Operational Amplifiers: Basic of op-amps, Op-amps circuit analysis, applications of op-amps-summer, subtractor, integrator, and differentiator, comparators, The Schmitt Triger, transfer function and Bode plots, frequency and time response of filters, active and passive filters, Sallen-key topology, Op-amp oscillators-Wien bridge and phase-shift oscillators, regulated power supply.
(No. of lectures- 18)

TEXT BOOKS / REFERENCE BOOKS:

1. Electronic Principles: Malvino and Bates (McGraw Hill Education)
2. The Art of Electronics: Horowitz and Hill (Cambridge University Press)
3. Integrated Electronics: Millman and Halkias (Tata McGraw Hill).
4. Op-Amps and Linear Integrated Circuits: Ramakanth A. Gayakwad (Prentice Hall of India)
5. Solid State Electronic Devices: Ben G. Streetman (Prentice Hall of India)
6. Electronic Devices and Circuit Theory: Robert Boylestad and Louis Nashdsky (Prentice Hall of India)

Lecture Plan

Lecture No.	Topics to be covered
1	Graphical analysis of the transistor operating in CE configuration
2	Two-port devices and Hybrid model
3	Determination of Hybrid parameters (h) from transistor characteristics
4	Conversion of h-parameters of three transistor modes
5	Emitter follower
6	Analysis of transistors amplifier circuit using h-parameters
7	Approximate expressions
8	High frequency effects in transistor
9	Graphical analysis of the transistor operating in CE configuration
10	Classification of amplifiers
11	Cascading of amplifiers
12-13	Frequency response of RC-coupled transistor amplifier
14-16	Power Amplifiers: Class A, B, C; Amplifier Characteristics,
17	Transfer gain of feedback amplifiers
18-19	basic feedback topologies and their properties: Voltage-series, Voltage-shunt,
20-21	Effect of negative feedback
22	Basic of op-amps, Slew rate, Open-loop and closed-loop gain, Bias and offset,
23	Inverting and non-inverting op-amps

24	Op-amp applications: summer, subtractor, integrator, and differentiator
25	Designing of amplifiers and Impedance Problem
26	Comparators
27	The Schmitt Trigger
28	Rectifier, peak-detector, clipper and clamper using op-amps
29	Transfer function and Bode plots
30-31	Frequency and time response of filters, Active Filters
32	Passive filters
33	Second order filters
34	Sallen-key topology
35-36	Op-amp oscillators: Wien bridge and phase-shift oscillators
37	Regulated Power Supply
38-39	Multivibrators

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT306	Astronomy & Astrophysics	4	3	1	0	0

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 sessional / mid-term and end term examinations.

PREREQUISITES:

1. Basic Mathematics (+2 Level).
2. Basic Thermodynamics & Classical Mechanics (Graduation Level).
3. Basic Quantum Mechanics. (Graduation Level).

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

Astronomy - Coordinate Systems For Celestial Objects & Their Interrelations, Cardinal Points In The Sky, Time Measurements in Astronomy, Proper & Peculiar Motion of Stars, Parallaxes, Photometry, Magnitude System, Distance Modulus, Color Indices. **(No. of lectures- 15)**

Astrophysics- - 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- 11)**

AstroLab- Astronomy softwares. Descriptive Astronomy & Planetary motions (Stellarium). Distance & Age of Open Cluster (Topcat), Double line Binary Star (Splatview). Handling of Photometers, CCD imaging devices & Telescopes. Astro-Python (Astropy & Sunpy) – Measurement of Solar Differential Rotation. Spotting GW events in the sky (Aladin)

(No. of Lab-sessions- 13)

TEXT BOOKS/ REFERENCE BOOKS: -

1. An Introduction to Modern Astrophysics : by B. W. Carrol & D. A. Ostlie (Addison Wesley)
2. Textbook of Astronomy & Atrophysics 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
8-10	Optical instruments
11	Parallax
12	Stellar Magnitude
13	Distance Modulus
14	Photometry
15	Color Indices
16-18	Stellar spectra and Structure
19-20	Ionization Equation & Elemental Abundances
21	Stellar Evolution
22	Nucleosynthesis and Formation of Elements
23	Variable stars
24	Compact stars

25	Star clusters
26	Binary Stars
27	Astronomy softwares. Descriptive Astronomy & Planetary motions (Stellarium).
28-29	Distance & Age of Open Cluster (Topcat),
30-31	Double line Binary Star (Splatview).
32-34	Handling of Photometers, CCD imaging devices & Telescopes.
35	Astro-Python (Astropy & Sunpy) –
36-37	Measurement of Solar Differential Rotation.
38-39	Spotting GW events in the sky (Aladin)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHP307	Analog Electronics Lab	2	0	0	4	0

COURSE CONTENTS

1. To study the characteristics of BJT amplifiers
2. To study the characteristics of MOSFET amplifiers
3. To study the characteristics of FET amplifiers
4. To study the frequency response of transistor amplifiers
5. To study the diode clipping and clamping
6. To study the voltage regulator using Zener diode
7. To study the class B push pull power amplifier
8. To study the application of op-amps as Inverting Amplifier, Non-inverting Amplifier, and Summing Amplifier
9. To study the application of op-amps as Integrator and Differentiator
10. To study the characteristics of Filters using op-amps: Low pass, High Pass, and Band Pass
11. To study the Schmitt Trigger using op-amps (positive feedback and Hysteresis)
12. To study the Wien Bridge Oscillator using op-amps
13. To design Precision Half-Wave and Full-wave Rectifiers using op-amps
14. To study the Multivibrators using op-amps

TEXT BOOKS/ REFERENCE BOOKS: -

1. Electronic Principles: Malvino and Bates (McGraw Hill Education).
2. The Art of Electronics: Horowitz and Hill (Cambridge University Press)
3. Integrated Electronics: Millman and Halkias (Tata McGraw Hill).
4. Op-Amps and Linear Integrated Circuits: Ramakanth A. Gayakwad (PHI)
5. Solid State Electronic Devices: Ben G. Streetman (PHI)
6. Electronic Devices and Circuit Theory: Robert Boylestad and Louis Nashdsky (PHI)
7. Operational Amplifiers & Linear Integrated Circuits: Theory and Application Laboratory Manual/3E, James M. Fiore (Dissident)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHP308	Electricity and Magnetism Lab	2	0	0	4	0

Experiment 1: Electrostatic Force − Measuring ε_0 (permittivity of free space)

Experiment 2: Magnetic Force on Current-Carrying Wires: To predict and verify the nature of the magnetic force acting on a current-carrying wire when the wire is placed in a magnetic field.

Experiment 3: Forces and Torques on Magnetic Dipoles: To measure the magnetic fields due to a pair of current-carrying loops in the "Helmholtz" configuration, both with the currents in the same direction and in the opposite direction.

Experiment 4: Magnetic Forces: To investigate the magnetic force between two current carrying wires and to measure the permeability constant µo. To measure the speed of light c with the help of experiment no. 1.

Experiment 5: Faraday's Law of Induction: To become familiar with the concepts of changing magnetic flux and induced current associated with Faraday's Law of Induction.

Experiment 6: LR and Undriven LRC Circuits: To determine the inductance L and internal resistance RL of a coil, both with and without an iron core, on the AC/DC Electronics Lab circuit board. To observe electrical oscillations, measure their frequencies, and verify energy relationships in an LRC circuit.

Experiment 7: Microwaves: To observe the polarization and angular dependence of radiation from a microwave generator and to measure the wavelength of the microwave radiation by analysing an interference pattern similar to a standing wave.

Experiment 8: e/m method

Experiment 9: Quincke's method

TEXT BOOKS/ REFERENCE BOOKS: -

1. Electricity and Magnetism" by Purcell E. Berkeley Physics course, vol 2.
2. Elements of Engineering Electromagnetics" by Sadiku M N O, Oxford University Press, 3rd Edition

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT401	Mathematical Methods in Physics – II	4	3	1	0	0

PREREQUISITE COURSES
Mathematical Methods in Physics - I

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, quizzes and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Systems of multiple variables - PDEs (separable solutions, discretization), wave equation, solution of Poisson's equation using Green's functions, connection to potentials, functionals and calculus of variations
(No. of lectures - 10)

Fourier Analysis - Fourier series, general properties, Fourier transform of continuum limit of Fourier series, Dirac delta function, Parsevals theorem and convolution theorem, Fourier transforms of common functions, uncertainty principle, reduction of PDEs
(No. of lectures - 10)

Probability and Statistics - Random variables, discrete vs continuous variables, probability distributions, expectation and variance, common distributions (binomial, Poisson, normal, gamma), multiple random variables, joint distributions, central limit theorem, information and entropy
(No. of lectures - 10)

Group Theory - Basic definitions, multiplication tables, non-Abelian groups, permutation groups, introduction to Lie groups, generators and symmetries, SO(2), SO(3) and SU(2) groups.
(No. of lectures - 9)

TEXT / REFERENCE BOOKS

1. *A Guided Tour of Mathematical Physics (Third Edition)*, Roel Snieder and Kasper van Wijk (Cambridge University Press)
2. *A Course in Mathematics for Students of Physics Vol. 1*, Paul Bamberg and Shlomo Sternberg (Cambridge University Press)
3. *Mathematical Methods for Physicists: A Concise Introduction*, Tai L. Chow (Cambridge University Press)
4. *Mathematics for Physics*, Michael Stone and Paul Goldbart (Cambridge University Press)
5. *Mathematical Methods for Physicists (Seventh Edition)*, George B. Arfken, Hans J. Weber, Frank E. Harris (Academic Press)
6. *Mathematical Physics - The Basics*, S. D. Joglekar (University Press) 2005
7. *Mathematical Physics: Advanced Topics*, S. D. Joglekar (University Press) 2006

Lecture Plan

Lecture No.	Topics to be covered
	Unit 1: Systems of multiple variables
1.	Recap of differential equations from earlier courses
2.	Partial differential equations – introduction, first order
3.	Partial differential equations – second order homogeneous
4.	Partial differential equations – separable solutions, completeness of solutions
5.	Partial differential equations – discretization for numerical methods
6.	Wave equation
7.	Poisson's equation
8.	Poisson's equation – Green's function
9.	Functionals, Calculus of variations
10.	Functionals, Calculus of variations – more examples
	Unit 2: Fourier Analysis
11.	Fourier series – introduction and basic properties
12.	Fourier series – basic properties
13.	Fourier transform as a continuum limit of Fourier series
14.	Dirac delta function
15.	Parsevals Theorem and Convolution Theorem
16.	Fourier transform of common functions
17.	Fourier transform of some more common functions
18.	Reduction of PDEs using Fourier transforms – basic idea and limitations
19.	Reduction of PDEs – returning to previously discussed PDEs
20.	Uncertainty principle
	Unit 3: Probability and Statistics
21.	Random variables, discrete vs continuous variables, probability distributions
22.	Moments. expectation and variance
23.	Discrete distributions - Binomial distribution
24.	Discrete distributions - Poisson distribution

25.	Continuous distributions - Normal distribution
26.	Continuous distributions - Gamma distribution
27.	Multiple random variables, joint distributions
28.	Multiple random variables, joint distributions contd.
29.	Central limit theorem
30.	Information and entropy
	Unit 4: Group Theory
31.	Basic definitions
32.	Multiplication tables and related theorems
33.	Non-Abelian groups
34.	Permutation groups
35.	Introduction to Lie groups
36.	Generators and symmetries
37.	SO(2) group
38.	SU(2) group
39.	SO(3) group

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT402	Condensed Matter Physics	4	3	1	0	0

PREREQUISITE – Quantum Mechanics

COURSE OBJECTIVE(s)
This course aims to equip the students with fundamental knowledge of condensed matter physics. To explain structural, electrical, and magnetic behavior of different types of condensed phases.

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

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

COURSE CONTENTS

Crystal Physics - Classification of condensed matter-crystalline and noncrystalline solids, bonding in solids - ionic, covalent and metallic solids, crystal symmetry, point groups, space groups, lattices and basis, typical crystal structures, reciprocal lattice, Brillouin zone, structure factor. Bragg's law of diffraction. **(No. of lectures- 10)**

Lattice Vibrations and Thermal Properties - Monoatomic and diatomic lattices, normal modes of lattice vibration, phonons and density of states, dispersion curves, specific heat – classical, Einstein and Debye models. thermal expansion and thermal conductivity, normal and Umklapp processes.

(No. of lectures- 9)

Band theory of solids - Free electron theory of metals, density of states, origin of energy bands, Fermi energy, Bloch Theorem, Kronig-Penney Model, distinction between metals, semiconductors, and insulators, Intrinsic and extrinsic semiconductors and carrier concentration, Hall effect in metals and semiconductors. **(No. of lectures- 9)**

Magnetism - Introduction to magnetism, quantum theory of dia- and para-magnetism, magnetic ordering, Weiss molecular theory of ferromagnetism and antiferromagnetism. Introduction to superconductivity, Meissner Effect, concept of Cooper pairs, BCS theory, Type-I and Type-II superconductors. **(No. of lectures- 12)**

TEXT/ REFERENCE BOOKS: -

1. Introduction to Solid State Physics, Kittel C, 8^{th} Ed. (Wiley Eastern Ltd. (2004))
2. Solid State Physics, Ashcroft N M and Mermin N D, 2^{nd} Ed. (Holt-Saunders (2004))
3. Solid State Physics, Hook J R and Hall H E (John Wiley and Sons (2001))
4. Magnetism in Condensed Matter, Blundell S (Oxford University press (2001))

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction and background
2.	Classification of condensed matter-crystalline and noncrystalline solids
3.	Bonding in solids - Ionic, covalent and metallic solids
4.	Bonding in solids - Ionic, covalent and metallic solids
5.	Crystal symmetry, point groups and space groups
6.	Lattices and basis
7.	Typical crystal structures,
8.	Introduction to reciprocal space and reciprocal lattice
9.	Brillouin zone, structure factor
10.	Bragg's law of diffraction
11.	Monoatomic and diatomic lattices
12.	Monoatomic and diatomic lattices
13.	Normal modes of lattice vibration
14.	Phonons, Density of states and dispersion curves
15.	Specific heat – classical, Einstein and Debye models.
16.	Specific heat – classical, Einstein and Debye models.
17.	Thermal expansion, thermal conductivity.
18.	Thermal expansion, thermal conductivity.
19.	Normal and Umklapp processes
20.	Free electron theory of metals
21.	density of states
22.	Origin of energy bands
23.	Fermi energy,
24.	Bloch Theorem, Kronig-Penney Model
25.	distinction between metals, semiconductors, and insulators
26.	Intrinsic and extrinsic semiconductors and carrier concentration
27.	Hall effect in metals and semiconductors.
28.	Introduction to magnetism
29.	Introduction to magnetism
30.	quantum theory of dia- and para-magnetism
31.	quantum theory of dia- and para-magnetism
32.	Weiss molecular theory of ferromagnetism and antiferromagnetism
33.	Weiss molecular theory of ferromagnetism and antiferromagnetism
34.	Introduction to superconductivity,
35.	Meissner Effect

36.	concept of Cooper pairs,
37.	BCS theory
38.	Type-I and Tupe-II superconductors.
39.	Course revision

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT403	Atomic & Molecular Physics	4	3	1	0	0

PREREQUISITE – Modern Physics, Quantum Mechanics

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of emission and absorption spectra of atoms and molecules, hydrogen atom, total angular momenta and dipole moment, coupling of angular momentum schemes of many electron atoms and effects of interaction of spectrum under different fields,

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 atom) - Introduction of atomic spectra (emission and absorption), Bohr model, Bohr model of one electron model, hydrogen spectra, Rydberg constant, Bohr's quantization law, spin-orbit interaction & fine structure, hyperfine structure, isotope shift, orbital angular momentum, magnetic dipole moment of electron, space quantization, Stern–Gerlach experiment, spin & total angular momentum, vector atom model.

(No. of lectures- 12)

Atomic Physics (Multi-electron atom) - Identical particles: exchange symmetry, Pauli exclusion principle, helium atom, introduction of central field approximation, angular momentum coupling schemes: LS & JJ coupling, interaction with external fields: Zeeman and Paschen-Back effect, Stark effect, general factors influencing spectral line width and intensities **(No. of lectures- 13)**

Molecular Physics - Born-Oppenheimer approximation, rotational spectra of diatomic molecules, type of molecules such (symmetric, spherical top etc.), vibrational spectra, diatomic vibrating rotator, vibration rotation spectra, electronic transitions, Franck- Condon principle, Raman effect (classical and quantum), Raman spectroscopy, Auger effect and spectroscopy, X-ray photoelectron spectroscopy

(No. of lectures- 14)

TEXT/ REFERENCE BOOKS:-

1. Atomic Physics by C.J. Foot, Oxford Master Series in Physics (Oxford University Press (2005))
2. Physics of atoms and molecules, B. H. Bransden and C. J. Joachain (Pearson)
3. Atomic and Molecular Spectra: Lasers by Raj Kumar (KNRN)
4. Fundamentals of Molecular Spectroscopy: C. N. Banwell and E. M. McCash (McGraw)
5. Introduction to Atomic Spectra: H. E. White (McGraw Hill)
6. Molecular Spectroscopy: K. V. Raman, R. Gopalan and P.S. Raghavan (Thomson)
7. Spectra of Atoms and Molecules: Peter F. Bernath (Oxford University Press)

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction of atomic spectra (emission and absorption)
2.	Bohr model, Bohr model of one electron model
3.	Hydrogen spectra
4.	Rydberg constant
5.	Bohr's quantization law
6.	Spin-orbit interaction & fine structure
7.	Hyperfine structure, Isotope shift
8.	Orbital angular momentum, Magnetic dipole moment of electron (Bohr magneton)
9.	Space quantization
10.	Spin & total angular momentum,
11.	Vector atom model
12.	Stern–Gerlach experiment
13.	Identical particles: exchange symmetry
14.	Pauli exclusion principle
15.	Helium atom (singlet and triplet)
16.	Introduction of Central field approximation
17.	LS coupling scheme (equivalent electron)
18.	LS coupling scheme (non-equivalent electron)
19.	JJ coupling scheme
20.	Normal Zeeman effect
21.	Anomalous Zeeman
22.	Paschen-Back effect
23.	Stark effect
24.	Spectral line width, Natural broadening
25.	Doppler broadening
26.	Born-Oppenheimer approximation
27.	Type of molecules such (symmetric, spherical top etc.)
28.	Rotational spectra of diatomic molecules, Rigid rotator
29.	Non-rigid rotator
30.	Vibrational spectra
31.	Simple harmonic Oscillator
32.	Diatomic vibrating rotator
33.	Vibration rotation spectra
34.	Electronic transitions, Franck- Condon principle

35.	Raman effect (classical)
36.	Raman effect (quantum)
37.	Raman spectroscopy
38.	Auger effect and spectroscopy,
39.	X-ray photoelectron spectroscopy

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT404	Digital Electronics	4	3	1	0	0

PREREQUISITE

Basic knowledge of algebra, and understanding of binary number system

COURSE OBJECTIVE(s)

The objective of a digital electronics course is to provide students with a comprehensive understanding of the fundamental principles, concepts, and techniques used in the design, analysis, and implementation of digital circuits and 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 on assignments, quizzes, and attendance)	20%
b)	Mid-term examination	30%
c)	End Semester Examination	50%

COURSE CONTENTS

Binary numbers and codes, error detection and correcting codes, universal gates and realization of AOI. simplification of logic circuit using Boolean algebra **(No. of Lectures - 8)**

Minterms and maxterms, conversion of a truth table into an equivalent logic circuit by (1) sum of products method and (2) product of sum method, Karnaugh map, arithmetic circuits: binary addition, binary subtraction using 2's complement method, programming logic devices

(No. of Lectures - 12)

Sequential Circuits: RS, D, and JK Flip-Flops. level clocked and edge triggered flip- flops, preset and clear operations. race-around conditions in JK Flip-Flops, master-slave JK flip-flop (as building block of sequential circuits), shift registers: serial-in-serial-out, serial-in-parallel-out, parallel-in-serial-out, and parallel-in-parallel-out shift registers (only upto 4 bits) **(No. of Lectures - 12)**

Counters: asynchronous and synchronous counters, ring counters, decade counter D/A and A/D conversion: D/A converter – resistive network. accuracy and resolution. timing circuit and display devices, concepts of microprocessor, microprocessor based system design

(No. of Lectures - 8)

TEXT/ REFERENCE BOOKS: -

1. Digital principles and applications By Donald P. Leach & Albert Paul Malvino,
2. Digital Fundamentals, 3rd Edition by Thomas L. Floyd
3. Digital Electronics by R.P. Jain
4. Fundamental of Digital Circuits, Anand Kumar
5. Microprocessor Architecture, Programming, and Applications with the 8085: R Gaonkar (Penram International Publishing)

Lecture Plan

Lecture No.	Topics to be covered
1.	Binary Number system and conversion
2.	Classification of binary codes
3.	Excess-3 codes
4.	Gray Codes
5.	Error detection codes
6.	Error corrcecting codes
7.	Universal gates and realization of AOI
8.	Simplification of Logic Circuit using Boolean Algebra
9.	Minterms and Maxterms
10.	Sum of Products Method (cont)
11.	Sum of Products Method
12.	Product of Sum method (cont)
13.	Product of Sum method
14.	Karnaugh Map
15.	Karnaugh Map (cont)
16.	Binary Addition. Using 2's Complement Method
17.	Binary Subtraction using 2's Complement Method
18.	Programming Logic Devices
19.	Read only Memmory (ROM)
20.	Programmable Read only Memmory (ROM)
21.	RS Flip Flops
22.	D flip flop
23.	J-K Flip flop
24.	Level Clocked and Edge Triggered Flip- Flops
25.	Preset and Clear Operations
26.	Race-around Conditions in JK Flip-Flops.
27.	Master-Slave JK Flip-Flop (Cont)

28.	Master-Slave JK Flip-Flop
29.	Shift registers (Cont)
30.	Shift registers (Cont)
31.	Shift registers (Cont)
32.	Shift registers
33.	Asynchronous and Synchronous Counters
34.	Ring Counters.
35.	Decade Counter
36.	D/A conversion
37.	A/D conversion
38.	Timing Circuit and display devices
39.	Concepts of Microprocessor, Microprocessor based system design

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT405	Statistics Mechanics	4	3	1	0	0

PREREQUISITE – Thermodynamics

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of statistical methods using microstates and contacts with thermodynamics, entropy, classical and quantum statistics and their applications

COURSE ASSESSMENT

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

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

COURSE CONTENTS

Basic concepts of Statistical Mechanics - Probability concepts and calculations, postulates of equal a priori probability, microstates and macrostates, Stirling's Approximation, phase space and quantum states, phase space cell, distribution function, density of states, contact between statistics and thermodynamics, statistical interpretation of entropy, classical ideal gas, entropy of mixing and the Gibbs paradox

(No. of lectures- 13)

Ensemble theory - Statistical ensemble, Liouville's theorem and its consequences, microcanonical ensemble; canonical ensemble, canonical partition function with examples, factorizability of partition function, grand canonical ensemble, grand partition function. **(No. of lectures- 11)**

Classical and Quantum Statistics - Distribution function for Maxwell–Boltzmann (MB), Bose-Einstein (BE) and Fermi- Dirac (FD) Statistics, classical ideal gas and distribution of speeds by MB statistics, ideal Bose gas, applications of BE statistics, Bose-Einstein condensation, energy and heat capacity, black body radiation, phonons, ideal Fermi gas, applications of FD statistics, electron gas in metals, Pauli paramagnetism, thermionic emissions, white dwarf stars. **(No. of lectures- 15)**

TEXT/ REFERENCE BOOKS:-

1. Statistical Mechanics, Kerson, 2nd Ed 2008 Huang (Wiley).
2. Fundamentals of Statistical and Thermal physics, Frederick Reif, (Waveland Pr Inc)
3. Statistical mechanics, R. K. Pathria, "", 3rd Ed. 2011 (Academic Press)
4. Statistical Mechanics An introduction, Evelyn Guha, 2013 (Narosa Publishing House)
5. Thermal Physics: Kinetic Theory, Thermodynamics and Statistical Mechanics, S.C. Garg, R.M. Bansal, C.K. Ghosh, 2e, 2017 (McGraw Hill Education (India))

Lecture Plan

Lecture No.	Topics to be covered
1	Probability concepts and calculations
2	Postulates of equal a priori probability
3	Microstates and macrostates
4	Stirling's Approximation
5	Phase space and Quantum states, phase space cell
6	Phase space examples
7	Distribution function, Density of states
8	Density of states
9	Contact between statistics and thermodynamics
10	Contact between statistics and thermodynamics
11	Statistical interpretation of entropy
12	Classical ideal gas, Entropy of mixing
13	Entropy of mixing and the Gibbs paradox
14	Basic of Statistical Ensemble
15	Liouville's theorem and its consequences
16	Liouville's theorem and its consequences
17	Microcanonical ensemble
18	Microcanonical ensemble with examples
19	Canonical ensemble
20	Canonical partition function with examples
21	Factorizability of partition function
22	Grand canonical ensemble
23	Grand canonical ensemble
24	Grand canonical partition function
25	Maxwell–Boltzmann Statistics
26	Distribution function for Maxwell–Boltzmann (MB)
27	Classical ideal gas and distribution of speeds by MB statistics
28	Bose-Einstein Statistics
29	Distribution function for Bose-Einstein (BE)
30	Applications of BE statistics, Ideal Bose gas
31	Bose-Einstein condensation
32	Energy and heat capacity, black body radiation, phonons
33	Fermi-Dirac Statistics
34	Distribution function for Fermi-Dirac (FD)
35	Applications of FD statistics, Ideal Fermi gas
36	Electron gas in metals

37	Pauli paramagnetism
38	Thermionic emissions
39	White dwarf stars

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHP406	Digital Electronics Lab	2	0	0	4	0

PREREQUISITE

Understanding of basic algebra of binary numbers, logic gates and circuits.

COURSE OBJECTIVE(s)

This course aims to equip the students with an understanding of the theoretical concept of digital electronics through laboratory and digital circuits, also understanding of designing and implementing combinational logic circuits, sequential circuits

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

1. To verify and design AND, OR, NOT, and XOR gates using NAND and NOR gates.
2. To derive all basic logic gates using NAND/NOR gates only
3. To design a 2-bit multiplier and implement it
4. Design half and full adder
5. Design half and full subtractor
6. Design a 4×1 Multiplexer using gates
7. To design and implement a latch using two NOR gates and verify its truth table
8. Design a counter using S-R, D/T/JK Flip-Flop
9. To realize the following shift registers using IC7474. (a) SISO (b) SIPO (c) PISO.
10. To implement a synchronous up/down counter

11. To realize 3-variable function using IC 74151
12. Clock-pulse generator: design, implement and test
13. Memory Unit: Investigate the behaviour of RAM unit and its storage capacity -16 X 4 RAM: testing, simulating and memory expansion
14. To perform 8 Bit Addition, Subtraction, Multiplication and Division by using MICROPROCESSORS (8086 Assembly Language Programming)

TEXT/ REFERENCE BOOKS: -

1. Digital principles and applications By Donald P. Leach & Albert Paul Malvino,
2. Digital Fundamentals, 3rd Edition by Thomas L. Floyd
3. Digital Electronics by R.P. Jain
4. Fundamental of Digital Circuits, Anand Kumar

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHP407	Solid State Physics Lab	2	0	0	4	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.

TEXT/ REFERENCE 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. Solid State Physics: Azaroff (McGraw Hill).
6. Solid State Physics: M.S. Rogalski and S.B. Palmer (Gordon & Breach Science Pub.).
7. Solid State Physics: Gerald Burns (Academic Press).

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
DC	24PHT501	Nuclear and Particle Physics	4	3	1	0	0

PREREQUISITE – Nuclear and Particle Physics

COURSE OBJECTIVE(s)
This course aims to equip the students with fundamental knowledge of nuclear and particle physics.

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 Concept - Units and dimensions, nuclear properties and forces: radius, size, mass, spin, moments, the abundance of nuclei, binding energy, deuteron, n-n and p-p interaction, nature of nuclear force**.**
(No. of lectures- 9)

Nuclear Models and Radioactivity - Basic liquid drop, shell, and collective models, theory of alpha decay, Fermi theory of beta decay, gamma decay. nuclear reactions: conservation laws, energetics, isospin, reaction cross-section. **(No. of lectures- 15)**

Particle Physics - Elementary particles- classification: Lepton, Hadron, forces, symmetries, conserved quantum numbers: Lepton number, Baryon number, strangeness, Charge, Isospin, mesons and Yukawa's hypothesis, quark model, Standard Model and Limitations, modern experimental facility in particle physics. **(No. of lectures- 15)**

TEXTBOOKS/ REFERENCE BOOKS: -

1. Introductory Nuclear Physics, S. Krane 2nd edition, (Wiley India Pvt. Ltd. 2013).
2. Nuclear physics, D.C. Tayal, 4th edition (Himalaya House, Bombay (1980)).
3. Concepts of Modern Physics, Arthur Bieser 7th edition (McGraw Hill Education 2009).

4. Introduction to elementary particles, David J. Griffiths (Wiley 1987)
5. Introduction to Quantum Electrodynamics and Particle Physics, Deep Chandra Joshi (I.K. International Publishing House Pvt. Ltd. 2006)
6. Introduction to nuclear and particle physics, Das and T. Ferbel (John Wiley (1994))

Lecture Plan

Lecture No.	Topics to be covered
1.	Units and Dimensions
2.	Nuclear properties and forces: radius, size
3	mass, spin
4.	moments
5.	the abundance of nuclei
6.	binding energy
7.	Deuteron
8.	n-n and p-p interaction
9.	nature of nuclear force
10-11	Basic liquid drop model
12-14	Shell Model
15-16	Collective model
16	Collective model
17-18	Theory of alpha decay
19-20	Fermi theory of beta decay
21	Gamma decay
22	Nuclear reactions: conservation laws, energetics
23	isospin
24.	reaction cross-section
25.	classification of elementary particles
26-27	Forces
28-30	Symmetries
31-32	Conserved quantum numbers
33-34	Mesons and Yukawa's hypothesis
35-36	Quark model
37-38	Standard Model
39	Standard Model drawbacks

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT502	Semiconductor Physics and Devices	4	3	1	0	0

PREREQUISITE – Quantum Mechanics, Condensed Matter Physics

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 low dimensional semiconductor structures and devices.

COURSE ASSESSMENT

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

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

COURSE CONTENTS

Review of band theory, direct & indirect band gap semiconductors, intrinsic & extrinsic semiconductors, Si & Ge crystal structures, growth of semiconductors, equilibrium charge carrier concentration, temperature dependence; optical injection, excess charge carriers, drift & diffusion current, generation/recombination, continuity equation, Haynes Shockley experiment **(No. of lectures- 13)**

P-N junction, equilibrium properties, space charge, capacitance of a junction, forward and reverse biased junctions, current-voltage characteristics, metal-semiconductor contacts, Schottky barrier, rectifying contacts, ohmic contact. **(No. of lectures- 10)**

Low dimensional semiconductors, band structure in one, two & three dimensions, density of states, heterostructures, band engineering, quantum wells & barriers, electrical transport, resonant tunneling, applications- high electron mobility transistor (HEMT), hetero bipolar junction transistors (HBJT), heterostructures in semiconductor laser **(No. of lectures- 16)**

TEXT/ REFERENCE BOOKS:-

1. Solid State Electronic Devices, B.G.Streetman, S. Banerjee, Prentice Hall
2. Semiconductor Physics and Devices- Basic Principles, Donald A. Neamen, 4th Ed., McGraw Hill
3. Semiconductor Devices Physics and Technology, S M Sze, John Wiley and Sons, 2nd Ed.
4. Semiconductor Materials and Devices, M S Tyagi, John Wiley and Sons
5. The Physics of Low Dimensional Semiconductors -An Introduction, Jhon H Davies

Lecture Plan

Lecture No.	Topics to be covered
1	Introduction to semiconductors
2	Band theory review, direct & indirect band gap semiconductors
3	Si & Ge Crystal structures
4	Growth of semiconductors
5	Intrinsic & extrinsic semiconductors
6	Equilibrium charge carrier concentration
7	Fermi level, Temperature dependence
8	Optical injection
9	Excess charge carriers
10	Drift & diffusion current
11	Generation/recombination
12	Continuity equation
13	Haynes-Shockley experiment
14	P-N junction
15-16	Equilibrium properties
17-18	Current-voltage characteristics
19	Metal-semiconductor contacts
20-21	Metal-semiconductor contacts (contd.)
22-23	Heterojunctions
24	Low dimensional semiconductors
25	band structure in one, two & three dimensions
26	band structure in one, two & three dimensions (contd.)
27	density of states,
28-29	Types of heterostructures
30	band engineering,
31-32	quantum wells & barriers
33-34	electrical transport
35-37	applications- HEMT, HBJT
38-39	heterostructures in semiconductor laser

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT503	Quantum Electronics	4	3	1	0	0

PREREQUISITE: Basic math (calculus) course, undergraduate electromagnetics, and semiconductors course.

COURSE OBJECTIVE(s): These objectives are designed to have a basic understanding of the fundamental concepts and operational principles of various optoelectronic devices for science and engineering applications.

COURSE ASSESSMENT

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

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

COURSE CONTENTS

Quantum Nature of Light and Matter, Schrödinger Equation and Stationary States, Harmonic Oscillator and Hydrogen Atom, Wave Mechanics **(No. of lectures- 8)**

Dirac Formalism and Matrix Mechanics, Harmonic Oscillator Revisited, Coherent States, Interaction of Light and Matter the Two-Level Atom: Rabi-Oscillations, Density Matrix, Energy and Phase Relaxation, Rate Equations, Dispersion, Absorption and Gain **(No. of lectures- 8)**

Introduction, Einstein's coefficients, Optical Amplification, Threshold condition, Laser rate equation, Variation of laser power around threshold, Optimum output coupling, Line broadening mechanism, Quality factor, Mode Selection: Transverse mode and longitudinal mode, Q-switching, Applications of Laser: Ruby Laser, He-Ne laser, and semiconductor laser. **(No. of lectures- 13)**

Light emitting diodes, LED characteristics, Electroluminescent process, choice of LED materials, device configuration, and efficiency, heterojunction LED, Surface-emitting LED, device performance characteristics, frequency response, and modulation bandwidth. Photoconductors, junction Photodiodes, PIN Photodiodes, heterojunction diodes, avalanche Photodiodes, Phototransistors, modulated barrier Photodiode, metal- semiconductor -metal photodiode. **(No. of lectures- 10)**

TEXT/ REFERENCE BOOKS: -

1. Quantum Electronics by A. Yariv (John-Willey)
2. Optical Electronics by A. K. Ghatak (Cambridge University Press)
3. Laser Fundamentals by T. Silfvast William (Cambridge University Press)
4. Principles of Lasers by Orazio Svelto (Springer)
5. Optoelectronics: An Introduction to Materials and Devices, Jasprit Singh (Tata McGraw Hill)

Lecture Plan

Lecture No.	Topics to be covered
1	Lasers: Basic introduction, Planck's radiation law (qualitative idea)
2	Lasers: Basic introduction, Planck's radiation law (qualitative idea)
3	Energy levels, Absorption process
4	Absorption process, Spontaneous and stimulated emission processes
5	Theory of laser action, Population of energy levels
6	Einstein's coefficients and optical amplification
7	Einstein's coefficients and optical amplification
8	Optical resonators and resonator stability
9	Modes of a spherical mirror resonator, mode selection
10	Q-switching, mode locking in lasers
11	Properties of laser beam and some applications of lasers: Ruby laser and He-Ne laser
12	Properties of laser beam and some applications of lasers: Ruby laser and He-Ne laser
13	Laser diode: Junction laser operating principles, threshold current
14	Heterojunction lasers, distributed feedback lasers
15	Cleaved coupled cavity laser, quantum well lasers
16	Modulation of lasers- rate equations, steady state solution
17	Transient phenomena and frequency response, relaxation oscillations and oscillating output
18	High frequency modulation of laser diodes
19	Fiber Optics: Fiber optic communication system
20	Ray propagation in optical fibers, Dispersion and losses in optical fibers
21	Ray propagation in optical fibers, Dispersion and losses in optical fibers
22	Modulation of light, Birefringence
23	Electro – Optic effect, Electro – optic modulators
24	Magneto-optic effect, Magneto – optic devices
25	Acousto-optic effect, Acoustic – optic modulators
26	Non-linear optoelectric effects

27	Structure of optical fiber
28	Propagation of light through optical fiber
29	Numerical aperture, Pulse broadening
30	Advantages and disadvantages of fiber optics
31	Optoelectronic Devices: Light emitting diodes
32	LED characteristics, Electroluminescent process
33	Choice of LED materials, device configuration, and efficiency
34	Heterojunction LED, Surface-emitting LED
35	Device performance characteristics, frequency response, and modulation bandwidth
36	Photoconductors, junction Photodiodes
37	PIN Photodiodes, heterojunction diodes
38	Avalanche Photodiodes, Phototransistors
39	Modulated barrier Photodiode, metal- semiconductor -metal photodiode

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT504	Thin film Science and Technology (24PHT601)	4	3	1	0	0

PREREQUISITE
None

COURSE OBJECTIVE(s)
This course aims to familiarize and equip the students with fundamental knowledge and working of vacuum pumps. Also, students learn how to synthesize and characterize thin films. The learned knowledge would help the students in research during their project.

COURSE OUTCOMES:

CO1	To understand the working of different vacuum pumps and vacuum leak detection techniques
CO2	Students would be able to learn about the growth of thin films using various deposition methods
CO3	An overview of different characterization techniques for thin films analysis
CO4	Apply the knowledge of Vacuum Science and Thin film technology in research and industry

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 vacuum science, creation of vacuum: rotary, diffusion, getter ion, turbo molecular, and cryo-pumps, measurement of vacuum: Penning, Pirani, ionization gauges, Designing a typical vacuum system, vacuum leak detection: Helium leak detector, Residual gas analyzer. **(No. of lectures- 10)**

Growth techniques of thin films: PVD & CVD methods, Thermal evaporation, E-beam evaporation, RF/DC sputtering, Pulsed Laser Deposition, Molecular Beam Epitaxy, Atomic Layer Deposition, Spin & dip coating, and Chemical vapour deposition. Film thickness measurement, Properties of thin films: Structural, optical, electrical and mechanical properties. **(No. of lectures- 16)**

Thin film analysis (with applications of techniques in solving research problems): ion beam sputtering, depth profiling, Study of inter diffusion in thin films using XPS, and RBS. Diffraction studies on thin films using XRD. Thin film morphological studies by SEM, STM and AFM. Applications of thin films in various fields. **(No. of lectures- 13)**

TEXT BOOKS/ REFERENCE BOOKS: -

1. Materials Science of Thin Films: Deposition and Structure, 2nd Edition, M. Ohring, 2001
2. Thin Film Phenomena. K. L. Chopra (McGraw-Hill)
3. Introduction to Nanoscience and Nanotechnology: K. K. Chattopadhyay and A.N. Banerjee, (PHI Learning Private Limited)
4. Vacuum Technology: A. Roth (North Holland)
5. Handbook of Thin Film Technology: Maissel and Glange (McGraw Hill)
6. Basic Vacuum Technology: A. Chambers, R. K. Fitch, B. S. Halliday
7. Elements of X-Ray Diffraction, B.D. Cullity & S.R. Stock

Lecture Plan

Lecture No.	Topics to be covered
1	Introduction to course syllabus
2	Basics of vacuum science
3	Creation of vacuum: rotary, diffusion
4	Creation of vacuum: Getter ion, Turbo molecular, and Cryo pumps
5	Measurement of vacuum: Penning & Pirani gauges
6	Ionization gauges
7	Designing a typical vacuum system
8	Vacuum leak detection: Helium leak detector
9	Residual gas analyser
10	Problems solving on Module 1
11	Growth techniques of thin films: PVD, CVD overview
12	Thermal evaporation
13	Electron beam evaporation
14	RF/DC Sputtering
15	Pulsed Laser Deposition
16	Molecular Beam Epitaxy
17	Atomic Layer Deposition
18	Spin coating
19	Dip coating
20	Chemical vapour deposition
21	Measurement of film thickness

22	Properties of thin films: Structural properties
23	Optical properties
24	Electrical properties
25	Mechanical properties
26	Problems solving on Module 2
27	Overview of thin film analysis
28	Thin films analysis by: ion beam sputtering
29	Depth profiling
30-31	Study of inter diffusion in thin films using: XPS
32-33	Study of inter diffusion in thin films using: RBS
34-35	Diffraction studies on thin films by XRD
36	Thin film morphological studies by: (a) SEM
37	(b) STM
38	(c) AFM
39	Applications of thin films in various fields

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHP505	Lasers and Optoelectronics Lab	2	0	0	4	0

PREREQUISITE: Basic understanding of laser and optoelectronic devices.

COURSE OBJECTIVE(s): To gain practical knowledge by applying the experimental methods to correlate with the Physics theory.

COURSE ASSESSMENT

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

S. No.	Component	Weightage
j)	Internal assessment (based upon practical lab records, viva, and attendance)	20%
k)	Mid-term examination	30%
l)	End Semester Examination	50%

Experiments

S. No.	List of Experiments
1.	To measure the beam divergence of laser (He-Ne Laser)
2.	To find the width of the wire or width of the slit using a diffraction pattern obtained by a He-Ne or solid-state laser.
3.	To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid-state laser.
4.	To study the characteristics of LDR.
5.	To determine the characteristics of Diode Laser.

6.	To calculate the spectral bandwidth of LEDs
7.	Study of Fabry Perot interferometer.
8.	To measure the wavelength of light using Precision interferometer (Michelson interferometer).
9.	To plot the graph and study the birefringence with respect to applied voltage in an electro optic crystal (Pockel Effect Apparatus)
10.	Determination of the Verdet constant of the material for a given wavelength of light (Magneto Optic Effect) Faraday Effect Apparatus
11.	To measure the numerical aperture of an optical fiber
12.	To determine the refractive index of optical fiber.
13.	To study the variation of the bending loss in a multimode fiber
14.	To determine the power loss at a splice between two multimode fiber
15.	To measure the split size of single mode fiber

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHP506	Nuclear and Spectroscopy Lab	2	0	0	4	0

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.
4. (b) To determine the linear and mass attenuation coefficients using gamma source using GM counter.
5. To study the electron spin resonance and to determine the Lande's g- factor.
6. To study normal Zeeman effect in transverse and longitudinal configurations.
7. To study the optical properties of polymer thin films grafted by fluorescence dye.
8. To measure the emission spectra of Hydrogen atom.
9. Lifetime of a short-lived radioactive source.
10. Compton Scattering Experiment to measure the scattering angle of scattered photons.
11. Resolving Time of G. M. Counter set-up.
12. To measure the Hydrogen Emission Spectra.
13. Alpha particle spectrometer: Energy resolved
14. Radiation Counter for Alpha and Beta Particles
15. $\chi 2$- Statistics using G. M. C

TEXT/ REFERENCE BOOKS:-

1. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
2. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
3. Particle Detectors: Claus Grupen and Boris Schwartz (Cambridge University Press).
4. Physics of Particle Detectors: Dan Green (Cambridge University Press).

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT601	Instrumentation Physics	4	3	1	0	0

PREREQUISITE
Basic mathematics, algebra, and basic physics

COURSE OBJECTIVE(s)

These objectives aim to provide students with a solid foundation in basic concept of instrumentation, measurement system and analytical instruments.

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

Basic concepts of Instrumentation: generalized instrumentation systems block diagram representation, scope of instrumentation in Industrial organization. **(No. of lectures- 5)**

Measurement systems: static (accuracy, sensitivity, linearity, precision, resolution, threshold, range, hysteresis, dead band, backlash, drift), impedance matching and loading, dynamic characteristics (types, fidelity, speed of response, dynamic error). **(No. of lectures- 7)**

Definition of errors- systematic errors, instrumental errors, environmental errors, random errors, loading errors, random errors, source of errors in measuring instruments, Uncertainties types, propagation of uncertainties), Data Analysis & Interpretation **(No. of lectures- 13)**

UV-visible spectrophotometer - Principle, working, applications, IR spectrophotometer - Principle, working, applications, X-ray spectrometry - Instrumentation for X - ray Spectrometry, Principle and working of X-ray Diffractometer, Raman Spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscope (AFM)

(No. of lectures- 14)

TEXT/ REFERENCE BOOKS: -

1. Doeblin& Manek, Measurement Systems, 4/e, McGraw Hill, New York, 1992,5th edition
2. Nakra & Choudhary ,Instrumentation Measurements and Analysis , Tata McGraw-Hill, 2nd edition
3. DVS Murthy, Measurement & Instrumentation, PHI
4. Arun K. Ghosh, Introduction to Measurements and Instrumentation, PHI, 4th edition
5. Hand book of Instrumental Techniques for Analytical Chemistry, Frank Settle, editor, Prentice Hall

Lecture Plan

Lecture No.	Topics to be covered
1	Basic concepts of Instrumentation
2	Generalized instrumentation systems (Cont)
3	Generalized instrumentation systems
4	Scope of instrumentation in Industrial organization (Cont)
5	Scope of instrumentation in Industrial organization
6	Measurement systems static characteristics (Cont)
7	Accuracy, sensitivity
8	Linearity, precision, resolution
9	Threshold, range, hysteresis,
10	Dead band, backlash, drift
11	Measurement systems dynamic characteristics (cont)
12	Types, fidelity, speed of response, dynamic error
13	Brief introduction of errors
14	Systematic errors
15	Instrumental errors
16	Random errors
17	Loading errors
18	Source of errors in measuring instruments
19	Uncertainties types
20	Propagation of uncertainties
21	Data Analysis & Interpretation (Cont)
22	Data Analysis & Interpretation (Cont)
23	Data Analysis & Interpretation
24	UV-visible spectrophotomete
25	Data Analysis & Interpretation
26	IR spectrophotometer
27	Data Analysis & Interpretation
28	X-ray spectrometry
29	Data Analysis & Interpretation
30	X-ray Diffractomete
31	Data Analysis & Interpretation
32	Scanning Electron Microscopy (SEM)
33	Data Analysis & Interpretation
34	Transmission Electron Microscopy (TEM)
35	Data Analysis & Interpretation

36	Atomic Dorce Microscopy (AFM)
37	Data Analysis & Interpretation
38	Raman Spectroscopy
39	Data Analysis & Interpretation

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHT602	Data Analysis & Interpretation	4	3	1	0	0

PREREQUISITES:
1. Basic Mathematics (+2 Level).
2. Basic Probability & Statistics (Graduation Level).
3. Basic Computer Skills (Graduation Level).

COURSE OBJECTIVES:
1. To impart fundamentals and application based knowledge education to Graduate students of Physics, primarily in areas: Data Analysis & Interpretation
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 pick optimal solutions within the ambit of available information.
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
1.	Internal assessment (based upon assignments, quizzes and attendance)	20%
2.	Mid-term examination	30%
3.	End Semester Examination	50%

COURSE CONTENTS

Statistical Inference, point estimation, confidence intervals, hypothesis testing, resampling methods, nonparametric statistics, univariate problems, bivariate & multivariate tests. Data smoothing, density estimation, histograms, kernel density estimators. Local regression. **(No. of lectures- 13)**

Correlation & Regression, multivariate analysis, multiple regression, logistic regression, principal component analysis, nonlinear regression; **(No. of lectures- 10)**

Classification of Data, Clustering & Data mining, k—means, supervised classification, classification trees, nearest neighbour classifier. Imputations & Nondetections. Survival analysis, Truncation. Time Series Analysis, AR models, 1/f noise. Spectral analysis. **(No. of lectures- 16)**

Textbooks & References

1. Modern Statistical Methods for Atronomy: E. D. Feigelson & G.J. Babu (Cambridge)
2. Textbook of Astronomy & Atrophysics with Elements of Cosmology : A. K. Chattopadhyay & T. Chattopadhyay (Springer)
3. Practical Statistics for Astronomers: J.V. Wall & C. R. Jenkins (Cambridge)
4. Statistics – Concepts & Applications: H. F. Althoen & S. C. Althoen (Cambridge)

Lecture Plan

Lecture No.	Topics to be covered
1	Statistical Inference
2	point estimation
3	confidence intervals,
4	hypothesis testing,
5	resampling methods,
6	nonparametric statistics,
7	univariate problems,
8	bivariate & multivariate tests.
9	Data smoothing,
10	density estimation,
11	histograms,
12	kernel density estimators.
13	Local Regression
14	Regression
15	multivariate analysis
16	multiple regression
17-18	Logistic regression
19-20	principal component analysis
21-23	nonlinear regression
24	Classification of Data
25	Clustering & Data mining
26-27	k—means
28	supervised classification
29-30	classification trees
31-32	nearest neighbour classifier
33	Imputations & Nondetections.
34	Survival analysis, Truncation.
35	Time Series Analysis

36	AR models
37	1/f noise.
38	Spectral analysis.
39	Recap.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PC	24PHP603	Advance Physics Lab	4	0	0	8	0

COURSE CONTENTS

Fabrication of Materials

1. Preparation of 3-D bulk materials (superconductor, ferromagnetic, ferroelectric) using solid state reaction method.
2. Synthesis of metal oxide particles by hydrothermal method.
3. Preparation of material/polymer composites using wet chemical method.
4. Determination of band gap of optical materials by UV-visible spectroscopy.
5. Determination of resistivity of Al and Cu thin film using four probe method (Van der Pauw method).
6. Determination of different modes of a Raman active material.
7. Determination of electrochemical activity of energy materials by electrochemical techniques.
8. Measurement of pressure, strain and torque using strain gauge.
9. Measuring change in resistance of Light Dependent Resistor (LDR) with light.
10. Measurement of displacement using Linear Variable Differential Transformers (LVDT).
11. Measurement of force and pressure using load cells.
12. Measurement of displacement using inductive transducer and capacitive transducer.
13. Measurement of Temperature using Temperature Sensors/RTDTo study the performance characteristics of an analog PID controller
14. Measurement of magnetic field and current using Hall effect sensors.

TEXT BOOKS/ REFERENCE BOOKS: -

1. Nanotechnology: Principles and Practices; S. K. Kulkarni, 3rd edition, Springer, 2014.
2. Polymer Synthesis and Characterization: A Laboratory Manual; S. S. Sandler et al. 1998.
3. Essentials of Inorganic Materials Synthesis; CNR Rao, K. Biswas, John Wiley & Sons, 2015
4. Rangan C S, Sharma G R and Mani V S V, “Instrumentation Devices and Systems”, 2nd Ed., Tata McGraw-Hill (2008)
5. Doebelin E O and Manik D N, “Measurement Systems”, 5th Ed., Tata McGraw-Hill (2008)
6. Cooper W D and Helfrick A D, “Modern Electronic Instrumentation and Measurement

Techniques", Pearson Education (2008).
7. Anand M M S, "Electronic Instruments and Instrumentation Technology", Pearson Education (2008).
8. Nakra B C and Chaudhry K K, "Instrumentation Measurements & Analysis" McGraw Hill (2002).
9. Sayer M and Mansingh A, "Measurement, Instrumentation & Experiment Design in Physics & Engineering", PHI (1999).

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

Program elective courses for B. Tech. (Engineering Physics)

S. No.	Course Type	Course Code	Title of the course	L-T-P	Credits
11.	PE	24PHTXXX	Surface Physics and Engineering	3-0-0	3
12.	PE	24PHTXXX	Materials Science and Engineering	3-0-0	3
13.	PE	24PHTXXX	LabVIEW for Beginners	2-0-2	3
14.	PE	24PHTXXX	Particle Detector and its Technology	3-0-0	3
15.	PE	24PHTXXX	Problem Solving in Physics with Python	2-0-2	3
16.	PE	24PHTXXX	Sensors: Materials, Fabrication & Applications	3-0-0	3
17.	PE	24PHTXXX	Introduction to Bio-inspired and bio-mimetic materials	3-0-0	3
18.	PE	24PHTXXX	Soft Materials	3-0-0	3

Advance elective courses for B. Tech. (Engineering Physics)

S. No.	Course Type	Course Code	Title of the course	L-T-P	Credits
4.	AE	24PHTXXX	Solar Energy and Physics of solar cells	3-0-0	3
5.	AE	24PHTXXX	Nanoscience and nanofabrication	3-0-0	3
6.	AE	24PHTXXX	Fundamentals of Energy Materials and Devices	3-0-0	3

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	Surface Physics and Engineering	3	3	0	0	0

PREREQUISITE – Condensed matter physics

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. In the later sections, students would know about the different surface characterization techniques and applications of surfaces. 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.

COURSE ASSESSMENT

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

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

COURSE CONTENTS

Physics of Surfaces- Introduction to surfaces and interfaces and their importance, from solid to surface, Gibbs adsorption equation, surface tension and surface energy, morphology and structure of surfaces, reciprocal lattice of the surface, surface relaxation and reconstruction, surface defects, surface creation; surface cleaning, adsorption (physisorption & chemisorption), desorption. **(No. of lectures - 10)**

Surface modifications and characterization techniques- Thermodynamics and kinetics of thin film growth, Surface Reactions: Catalysis, Crystal Growth, Chemical Reactions & Nucleation, Homogeneous nucleation kinetics, Thin Film Deposition and Surface modifications by physical vapour deposition, chemical vapour deposition, Advanced Surface Modification Practices, Auger Electron Spectroscopy, X-ray Photoelectron Spectroscopy, Secondary Ion Mass spectroscopy, Scanning Probe Microscopy: Scanning Tunnelling Microscopy, Atomic Force Microscopy, Surface structure determination by electron diffraction (LEED, RHEED). **(No. of lectures - 14)**

Surfaces engineering applications- Surface coatings, Functional Coatings, Advanced Coating Practices, Applications of Nano-coatings, mechanical, physical, chemical and other properties nanostructured coatings, tribology & Its Classification, types and laws of friction, methods to control friction, Wear & Corrosion, Lubrication, Effect of Tribology on Surface of Nanomaterials, hard coatings and hardness measurements, optical applications of surfaces, Catalytic applications of surfaces, electrochemical and energy applications of nanomaterials. Semiconducting surfaces applications. Bio applications of surfaces.

(No. of lectures - 15)

TEXT/ REFERENCE BOOKS: -

1. Surface Science- An Introduction, K Oura (Springer).
2. Surface Analysis: The Principal Techniques, John C. Vickerman, Ian S. Gilmore (Wiley).
3. Materials Degradation and its control by surface engineering, Imperial College Press, (2006)
4. Materials and Surface Engineering in Tribology, Willey (2007), London A W Batchelor et al.
5. Physics of Surfaces and Interfaces, Haralad Ibach (Springer).
6. Surface engineering in metals, CRC Press (1999) London
7. Solid Surfaces, Interfaces and Thin Films, Hans Luth (Springer).

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction to surfaces and interfaces
2.	Surfaces and Interfaces and their importance
3.	Morphology and Structure of Surfaces
4.	Basics of Scanning Tunneling Microscopy
5.	Surface relaxation
6.	Surface reconstruction
7.	Surface Defects (line and point defects)
8.	Surface Creation; Surface cleaning
9.	Physisorption & Chemisorption
10.	Desorption
11.	Significance of vacuum for surface studies
12.	Vacuum pumps and vacuum gauges
13.	Diffusion and surface-controlled growth
14.	Fundamentals of thin film growth
15.	Surface modifications by physical and chemical routes
16.	Introduction to electron spectroscopies
17.	Electron energy analysers
18.	Auger Electron Spectroscopy
19.	X-ray Photoelectron Spectroscopy
20.	X-ray Photoelectron Spectroscopy
21.	Secondary Ion Mass spectroscopy
22.	Surface structure determination by LEED and RHEED
23.	Scanning Probe Microscopy (Scanning Tunneling Microscopy)
24.	Scanning Probe Microscopy (Atomic Force Microscopy)
25.	Surface coatings
26.	Functional Coatings
27.	Advanced Coating Practices
28.	Properties nanostructured coatings
29.	Applications of Nano-coatings

30.	Optical applications of surfaces
31.	Semiconducting surfaces applications
32.	Catalytic applications of surfaces
33.	Electrochemical and energy applications of nanomaterials
34.	Bio applications of surfaces
35.	Mechanical applications of coatings (tribology & Its Classification)
36.	Hard coatings and hardness measurements techniques
37.	Wear & Corrosion, lubrication
38.	Effect of Tribology on Surface of Nanomaterials
39.	Types and laws of friction, methods to control friction

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	Materials Science and Engineering	3	3	0	0	0

PREREQUISITE – Quantum Mechanics, Condensed Matter Physics

COURSE OBJECTIVE(s)
This course aims to provide the students an introduction to materials science and engineering, including real world applications and problems.

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

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

COURSE CONTENTS

Classification of engineering materials, imperfections in crystals -point & linear defects, dislocations and their properties, surface imperfections, grain size determination **(No. of lectures- 06)**

Diffusion in solids- Diffusion mechanisms, steady state diffusion, nonsteady state diffusion, applications based on second low of diffusion, atomic model of diffusion, factors affecting diffusion
(No. of lectures- 06)

Phase diagrams & phase transformations- solubility limit, phases & phase rule, binary isomorphous systems, interpretation of phase diagrams, binary eutectic systems, eutectoid & peritectic reactions, some typical phase diagrams, kinetics of phase transformations, nucleation & growth, applications.
(No. of lectures- 12)

Structure & properties of ceramics, crystal structures, silicates, imperfections diffusion, applications and processing of ceramics: classification of polymers, addition & condensation polymerization, degree of polymerization, thermoplastic & thermosetting polymers, defects in polymers, effect of temperature, polymer processing & recycling. **(No. of lectures- 09)**

Corrosion & degradation of materials- electrochemical properties, mechanisms of corrosion, corrosion rates, passivity, forms of corrosion, corrosion environments & corrosion preventions, oxidation, degradations in ceramics and polymers. **(No. of lectures- 06)**

TEXT/ REFERENCE BOOKS:-

1. Materials Science and Engineering, V. Raghavan, PHI
2. Materials Science and Engineering An Introduction, William D. Callister, Jr, Wiley
3. Essentials of Materials Science and Engineering, Donald R. Askeland & Pradeep P. Phule, CENGAGE Learning

Lecture Plan

Lecture No.	Topics to be covered
1.	Classification of engineering materials
2.	imperfections in crystals -point & linear defects
3.	dislocations and their properties
4.	dislocations and their properties
5.	surface imperfections
6.	grain size determination
7.	Diffusion in solids- Diffusion mechanisms,
8.	steady state diffusion
9.	nonsteady state diffusion,
10.	applications based on second low of diffusion
11.	atomic model of diffusion
12.	factors affecting diffusion
13.	Introduction, solubility limit
14.	phases & phase rule,
15.	binary isomorphous systems
16.	interpretation of phase diagrams,
17.	binary eutectic systems
18.	binary eutectic systems
19.	binary eutectic systems
20.	eutectoid & peritectic reactions
21.	some typical phase diagrams
22.	kinetics of phase transformations
23.	nucleation & growth
24.	applications
25.	Structure & properties of ceramics,
26.	crystal structures, silicates
27.	imperfections diffusion

28.	applications and processing of ceramics
29.	classification of polymers
30.	addition & condensation polymerization, degree of polymerization
31.	thermoplastic & thermosetting polymers
32.	defects in polymers, effect of temperature
33.	polymer processing & recycling
34.	electrochemical properties
35.	mechanisms of corrosion, corrosion rates
36.	passivity, forms of corrosion
37.	corrosion environments & corrosion preventions
38.	oxidation,
39.	degradations in ceramics and polymers

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	LabVIEW for Beginners	3	2	0	2	0

PREREQUISITE – None

COURSE OBJECTIVE(s)
After completing this course, the student should be able to write LabVIEW code to simulate or analyze their data. Students should be able to interface various instruments to acquire data. In addition, they will be able to design/write LabVIEW code to perform an experiment according to their/industry requirements. It will 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 users.

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

Introduction of the LabVIEW, Graphical Programming Language, LabVIEW Environment, Components of Virtual Instruments, Data flow in LabView, Controls, Indicators, and Function Palettes.
(No. of lectures- 6)

Simple Algorithm, Creating VI, Debugging the Errors, Structures and Loops, Decision-Making Algorithm, Math Script, and Sequence. **(No. of lectures- 4)**

Arrays, Clusters, Conversion of Arrays to Cluster and Matrix, Conversion of Clusters and Matrix to Arrays; String, Modular programming and sub-Vis, Charts and Graphs. **(No. of lectures- 8)**

Input and Out Files handling, Simulating Signals and Analyzing the input Signals, Instrument Interfacing and Data Acquisition, Hands-on Practice: Interfacing and Data Acquisition from Various Lab Instruments.
(No. of lectures- 8)

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).
5. Lab View User Manual, National Instruments (NI)

Lecture Plan

Lecture No.	Topics to be covered
1	What is LabVIEW
2	LabVIEW Environment and Creating New VI
3	Components of Virtual Instruments
4	Data flow in LabView
5	Controls, Indicators
6	Function Palettes
7	Simple Algorithm, Creating VI, and Debugging the Errors
8	Structures and Loops
9	Decision-Making Algorithm
10	Math Script and Sequence
11-12	Arrays and Clusters
13	Conversion of Arrays to Cluster and matrix
14	Conversion of Clusters and Matrix to Arrays
15	String
16-17	Modular programming and sub-Vis
18	Charts and Graphs.
19	Input and Out Files handling,
20-21	Simulate Signals
22-24	Analyze the input Signals
25	Introduction to Data Acquisition
26	Interfacing Instruments

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	Particle Detector and its Technology	3	3	0	0	0

PREREQUISITE – Particle Detector and Technology

COURSE OBJECTIVE(s)
This course aims to equip the students with fundamental knowledge of Particle Detector and Technology.

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

Overview of the detector technology used in particle physics experiments starting from the Rutherford scattering experiment to the present world's largest experiments at the Large Hadron Collider (LHC), basic concept of energy loss by excitation and ionization, Bethe-Bloch formula, density effects, mean energy loss as a function of velocity, fluctuations in energy loss, interaction of electrons with matter: Bremsstrahlung, interaction of photon with matter: photo-electric effect, Compton scattering, pair production.

(No. of lectures- 6)

Fundamental physics principle of particle detectors: ionization and excitation, construction, working, and operational characteristics of particle detectors: gaseous detectors, ionization chambers, proportional counters, drift chambers, bubble chambers, semiconductor detectors: introduce silicon detectors technology, pixel and strip detectors, CCDs, electromagnetic calorimetry, hadronic calorimetry, general characteristics of particle detectors, development of a detector system concepts.

(No. of lectures- 11)

Signal formation, electronic noise, optimization of signal-to-noise ratio, pulse processing electronics, amplification, applications: position, tracking, and energy measurements in modern particle physics experiments, radiation detection in space applications: advanced space radiation detector technology at NASA, radiation detectors for medical imaging: beam monitoring and 3D imaging, nuclear techniques for material analysis. **(No. of lectures- 9)**

TEXTBOOKS/ REFERENCE BOOKS: -

1. Techniques for Nuclear and Particle Physics Experiment: W. R. Leo (Springer).
2. Radiation Detection and Measurement: Glenn F. Knoll (Wiley).
3. Particle Detectors: Claus Grupen and Boris Schwartz (Cambridge University Press).
4. Physics of Particle Detectors: Dan Green (Cambridge University Press).
5. Evaluation of Silicon sensor technology in particle physics: Frank Hartmann (Springer).
6. Semiconductor Radiation Detectors, Device Physics: Gerhard Lutz (Springer).
7. Handbook of Particle Detection and Imaging: Grupen, Claus, Buvat, Irene (Springer).

Lecture Plan

Lecture No.	Topics to be covered
1.	Overview of the detector technology used in particle physics experiments, starting from the Rutherford scattering experiment to the present world's largest experiments at the Large Hadron Collider (LHC)
2.	Basic concept of energy loss by excitation and ionization
3	Bethe-Bloch formula, density effects, mean energy loss as a function of velocity, fluctuations in energy loss
4.	interaction of electrons with matter: Bremsstrahlung
5.	interaction of photon with matter: photo-electric effect, Compton scattering
6.	pair production.
7.	Fundamental physics principle of particle detectors: ionization and excitation
8.	construction, working, and operational characteristics of particle detectors: gaseous detectors
9.	ionization chambers
10.	proportional counters
11	drift chambers
12	bubble chambers
13	semiconductor detectors: introduce silicon detector technology
14	pixel and strip detectors, CCDs
15	electromagnetic calorimetry, hadronic calorimetry
16	general characteristics of particle detectors
17	development of a detector system concept
18.	Signal formation, electronic noise
19.	optimization of signal-to-noise ratio
20.	pulse processing electronics, amplification
21.	applications: position, tracking
22.	energy measurements in modern particle physics experiments
23.	radiation detection in space applications: advanced space radiation detector technology at NASA
24.	radiation detectors for medical imaging: beam monitoring and 3D imaging

25.	radiation detectors for medical imaging: beam monitoring and 3D imaging
26.	nuclear techniques for material analysis

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	Problem Solving in Physics with Python	3	2	0	2	0

PREREQUISITE –

COURSE OBJECTIVE(s)
This course aims to equip the students with Python Programming and how to solve Physics problems 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

Overview on the open sources for Python, for example Jupyter notebook, Google Colab etc. variables and Data Types, string: methods and manipulation, logical operators and conditional statements

(No. of lectures- 7)

Loops: for loop, nested for loops, the While loops.
Collections: tuples, dictionaries, nested data structures , functions (default and user defined), modules in Python: math module, random module, errors. **(No. of lectures- 8)**

Introduction to Plotting (Graphs) in Python with Matplotlib, a brief Introduction to the Numpy Module: Numpy arrays and lists, representing matrices and matrix multiplication, matrices and linear systems, solving problems of physics using Python functions and modules, differential equations, Monte Carlo techniques. **(No. of lectures- 11)**

TEXT BOOKS/ REFERENCE BOOKS: -

1. Python from the Very Beginning, John Whitington, ISBN-13: 978-0-9576711-5-7 238 Pages (Second edition, May 2023).
2. Python Machine Learning - Second Edition, Sebastian Raschka , Vahid Mirjalili
3. Introduction to Machine Learning with Python, Andreas C. Müller & Sarah Guido

4. John R. Taylor. An Introduction to Error Analysis. University Science Books, 2 edition, 1997.
5. Shai Vaingast. Beginning Python Visualization: Crafting Visual Transformation Scripts. Apress, 2009.
6. Tao Pang. An Introduction to Computational Physics. Cambridge University Press, 2nd edition, 2006.

Lecture Plan

Lecture No.	Topics to be covered
1	Overview on the open sources for Python, for example Jupyter notebook, Google Colab etc
2	Variables and Data Types
3-4	Variables and Data Types
5-7	String :Methods and Manipulation Logical operators and Conditional Statements
8	Loops
9	Tuples
10	Dictionaries
11	Nested Data Structures
12	Functions
13	Math Module
14	Random Module
15	Errors
16-17	Introduction to Plotting (Graphs) in Python with Matplotlib
18-19	A brief Introduction to the Numpy Module: Numpy arrays and lists
20-22	Representing matrices and matrix multiplication, Matrices and linear systems
23-24	Solving problems of physics using Python functions and modules
25	Differential equations
26	Monte Carlo Techniques

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	Sensors: Materials, Fabrication & Applications	3	3	0	0	0

PREREQUISITE
Basic understanding of sensors

COURSE OBJECTIVE(s)

These objectives aim to provide students with an overview of sensor fabrication and its application in various fields.

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

Functional elements of a measurement system and instruments, Types of measured Quantities, General concepts and terminology of Sensor systems, Transducers classification-sensors and actuators,. Importance of nanoscale materials for sensing applications, Approaches used for characterizing sensors based nanomaterials, Approaches used for tailoring nanomaterials for a specific sensing application, Metallic and semiconductor nanoparticles, Optical, mechanical and chemical sensors based on nanomaterials, Hybrid nanomaterial-based sensors. **(No. of lectures: 10)**

Role of Wearables, Attributes of Wearables, The Meta Wearables – Textiles and clothing, Social Aspects: Interpretation of Aesthetics, Adoption of Innovation, On-Body Interaction; Case Study: Google Glass, health monitoring, Wearables: Challenges and Opportunities. Motivation for the development of Wearable Devices, The emergence of wearable computing and wearable electronics, Types of wearable sensors: Invasive, Non-invasive; Intelligent clothing, **(No. of lectures: 08)**

Fabrication of interdigitated (IDE) electrodes, choice of substrate, sensing film; Wearable Bioelectric impedance devices for Galvanic skin response; Basic Measurement set-up, electrodes, and instrumentation; Materials for Microfluidic Devices-Silicon, Glass, Polymer. Disposable smart lab-on-a-chip sensors

(No. of lectures: 06)

Wearable Biochemical Sensors: Parameters of interest, System Design –Textile based, Microneedle based; Types: Noninvasive Glucose Monitoring Devices; Pulse oximeter, Portable Pulse Oximeters, wearable pulse oximeter; Wearable capnometer for monitoring of expired carbon dioxide. Wearable gas sensors: Metal Oxide (MOS) type, electrochemical type, new materials-CNTs, graphene, Zeolites; Detection of atmospheric pollutants. **(No. of lectures: 08)**

Wearable Blood Pressure (BP) Measurement: Cuff-based sphygmomanometer, Cuffless Blood Pressure Monitor. Study of flexible and wearable Piezoresistive sensors for cuffless blood pressure measurement. Wearable sensors for Body Temperature: Intermittent and Continuous temperature monitoring, Detection principles – thermistor, infrared radiation. Knitted Piezoresistive Fabric (KPF) sensors. Sensor Design and Packaging: Partitioning, Layout, technology constraints, scaling, compatibility study.

(No. of lectures: 07)

TEXT/ REFERENCE BOOKS: -

1. Instrumentation, Measurement and Analysis, Nakra & Choudhury (Tata McGraw)
2. Hand Book of Modern Sensors: physics, Designs and Applications, Jacob Fraden (Springer)
3. Wearable Sensors: Fundamentals, Implementation and Applications, Sazonov and Neuman (Elsevier)
4. Wearable Electronics Sensors-For Safe and Healthy Living, S. C. Mukhopadhyay (Springer)

Lecture Plan

Lecture No.	Topics to be covered
1	Functional Elements of a Measurement System and Instruments
2	Applications and Classification of Instruments
3	Types of measured Quantities
4	General concepts and terminology of Sensor systems
5	Transducers classification-sensors and actuators,.
6	Importance of nanoscale materials for sensing applications
7	Approaches used for tailoring nanomaterials for a specific sensing application
8	Metallic and semiconductor nanoparticle
9	Optical, mechanical and chemical sensors based on nanomaterials
10	Hybrid nanomaterial-based sensors
11	Role amd Attributes of Wearables
12	The Meta Wearables – Textiles and clothing
13	Social Aspects: Interpretation of Aesthetics, Adoption of Innovation,
14	Case Study: Google Glass, health monitoring
15	Wearables: Challenges and Opportunities.
16	Motivation for the development of Wearable Devices
17	The emergence of wearable computing and wearable electronic
18	Types of wearable sensors: Invasive, Non-invasive; Intelligent clothing

19	Fabrication of interdigitated (IDE) electrodes
20	Choice of substrate, sensing film
21	Wearable Bioelectric impedance devices for Galvanic skin response
22	Basic Measurement set-up, electrodes, and instrumentation
23	Materials for Microfluidic Devices
24	Disposable smart lab-on-a-chip sensors
25	Wearable Biochemical Sensors: Parameters of interest
26	System Design –Textile based, Microneedle based
27	Noninvasive Glucose Monitoring Devices; Pulse oximeter,
28	Portable Pulse Oximeters, wearable pulse oximeter;
29	Wearable capnometer for monitoring of expired carbon dioxide.
30	Wearable gas sensors: MOS type
31	Electrochemical type
32	Detection of atmospheric pollutants.
33	Wearable Blood Pressure (BP) Measurement
34	Study of flexible and wearable Piezoresistive sensors
35	Wearable sensors for Body Temperature
36	Detection principles – thermistor, infrared radiation
37	Knitted Piezoresistive Fabric (KPF) sensors.
38	Sensor Design and Packaging (cont)
39	Sensor Design and Packaging

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	Introduction to Bio-inspired and bio-mimetic materials	3	0	0	0	0

PREREQUISITE – Basic knowledge of biology, materials science, and engineering principles is required to comprehend the course material effectively.

COURSE OBJECTIVE(s)
This course aims to gain insight into biological and bioinspired materials, nanotechnology, and tissue engineering, with a focus on understanding design principles and applications in varios fields inspired from nature.

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 biological and bio inspired materials, biomimetic and bioinspired engineering, inspiration from nature, bio-inspired designs, biological engineering principles, basic building blocks found in biological materials, adhesive surfaces, gecko inspired adhesion, lotus surface, nature against nature: repellency against adhesion, bio-inspired nanostructures, biosensors **(No. of lectures- 12)**

Introduction to nanotechnology, surface engineering, bio-inspired nanoparticles, biological membranes, polymer-reinforced and ceramic-toughened composites, lightweight biological and bioinspired materials, bio-functional interfaces, components of a bio-functional interface and fabrication, biocompatibility vs. bio-functionality, bio-inspired functional interfaces, characterization of bio-functional interfaces **(No. of lectures- 14)**

Introduction to tissue engineering, bio-inspired scaffolds for tissue engineering, self-healing and adaptive materials, bio-sensing, components of a biosensor, nature-inspired sensing, drug delivery, smart targeted drug delivery, micro and nano robots, lab-on-chip devices, examples of bio-inspired lab on chip devices, examples of organs on chips, modelling diseases on a chip **(No. of lectures- 13)**

TEXT/ REFERENCE BOOKS:-

1. Bio and bioinspired nanomaterials: Daniel Ruiz-Molina, F. Novio, C. Roscini (WileyVCH).
2. Bioinspired approaches for human-centric technologies: Roberto Cingolani (Springer).
3. Biological materials science: M. A. Meyers and P-Y. Chen (Cambridge).
4. Biomimetics, biologically inspired technologies: Yoseph Bar-Cohen (Taylor and Francis).
5. Materials design inspired by nature: P. Fratzl, J. W. C. Dunlop and R. Weinkamer (RSC).
6. Nanobiotechnology: Oded Shoseyov and Ilan levy (Human Press).

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction to biological material
2.	Introduction to bio inspired material
3.	Biomimetic and bioinspired engineering
4.	Examples for inspiration from nature
5.	Bio-inspired designs,
6.	Biological engineering principles
7.	Basic building blocks found in biological materials
8.	Adhesive surfaces, gecko inspired adhesion
9.	Lotus surface properties and inspiration
10.	Nature against nature: repellency against adhesion
11.	Bio-inspired nanostructures
12.	Biosensors
13.	Introduction to nanotechnology
14.	Surface engineering
15.	Bio-inspired nanoparticles
16.	Biological membrane
17.	Synthetic membranes having similar function as biological membranes
18.	Polymer-reinforced composites
19.	Ceramic-toughened composites
20.	Lightweight biological and bioinspired materials
21.	Bio-functional interfaces
22.	Components of a bio-functional interface and fabrication
23.	Biocompatibility vs. bio-functionality
24.	Bio-inspired functional interfaces,
25.	Characterization of bio-functional interfaces (Cont)
26.	Characterization of bio-functional interfaces
27.	Introduction to tissue engineering
28.	Bio-inspired scaffolds for tissue engineering (Cont)
29.	Bio-inspired scaffolds for tissue engineering
30.	Self-healing and adaptive materials
31.	Components of a biosensor
32.	Nature-inspired sensing

33.	Drug delivery
34.	Targeted drug delivery
35.	Micro and nano robots
36.	Lab-on-chip devices
37.	Examples of bio-inspired lab on chip devices
38.	Examples of organs on chips
39.	Modelling diseases on a chip

DEPARTMENT OF PHYSICS

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
PE	24PHTXXX	Soft Materials	3	3	0	0	0

PREREQUISITE – Basic knowledge of materials science, particularly in polymers and colloidal systems, is recommended.

COURSE OBJECTIVE(s)
This course provides an introduction to the fundamental principles, properties, and applications of soft materials including their classification and unique properties, and explore the transition from hard to soft building blocks in colloidal 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

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)**

TEXT/ REFERENCE 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)
6. 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

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
AE	24PHTXXX	Solar Energy and Physics of solar cells	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
g)	Internal assessment (based upon assignments, quizzes and attendance)	20%
h)	Mid-term examination	30%
i)	End Semester Examination	50%

COURSE CONTENTS

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, photo thermal conversion, types of solar energy collectors, solar fuels: electrolysis of water, photoelectrochemical splitting of water. **(No. of lectures - 10)**

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 - 9)**

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, PV modules, systems, and reliability, Cost, Price, Markets, & Support Mechanisms, R&D Investment & Innovation in PV. **(No. of lectures - 10)**

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.	Introduction to the course syllabus
2.	Solar constant, spectral distribution of solar radiation
3.	Absorption of solar radiation in the atmosphere
4.	Seasonal and daily variation of solar radiation
5.	Measurement of solar irradiation, global and diffused radiation
6.	Solar to thermal energy conversion, Solar to thermal to electrical energy conversion
7.	Solar fuels: hydrogen, Hydrogen production processes
8.	Hydrogen generation: Electrolysis of water, Photoelectrochemical (PEC) splitting of water
9.	Fundamentals of solar cells: photo voltaic effect
10.	p-n junction photodiodes, Depletion region, electron and holes transports
11.	Absorption of photons
12.	Surface structures for maximum light absorption
13.	Thermalization losses
14.	Concept of multijunction solar cells
15.	Excitons and photoemission of electrons
16.	Semiconductor band engineering
17.	Charge carrier generation and transport

18.	Charge separation
19.	Recombination and other losses, and time constants
20.	I-V characteristics of a diode: under dark and illumination
21.	Output power, types of efficiencies
22.	Fill factor and optimization for maximum power
23.	Metal-semiconductor junctions
24.	Operating temperature vs conversion efficiency
25.	Introduction to device physics: Device structures
26.	Introduction to device physics: Device construction
27.	Solar cell properties and design
28.	Materials for solar cells
29.	Thin film materials: choices and manufacturing
30.	PV efficiency: measurement and theoretical limits
31.	Solar cell characterization
32.	Silicon based solar cells: single crystal, polycrystalline and amorphous silicon solar cells
33.	Advanced concepts in photovoltaic research: Organic solar cells, organic-inorganic hybrid solar cells
34.	Advanced concepts in photovoltaic research: perovskite based solar cells
35.	Nanotechnology applications and quantum dots
36.	PV modules, systems, and reliability
37.	Cost, Price, Markets, & Support Mechanisms
38.	R&D Investment & Innovation in PV
39.	Review of the classes, resolving queries, and conclusion

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
AE	24PHTXXX	Nanoscience and nanofabrication	3	3	0	0	0

PREREQUISITE – Quantum Mechanics, Condensed Matter Physics

COURSE OBJECTIVE(s)

This course aims to equip the students with fundamental knowledge of nanoscience and nanotechnology topics. To explain structural, electrical, and magnetic properties of different types of nanostructures. The fabrication process for nanostructures and micro-nano devices.

COURSE ASSESSMENT

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

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

COURSE CONTENTS

Physical Properties of Nanomaterials - effect of size on thermal, electrical, mechanical, optical and magnetic properties of nanoscale materials, diffusion properties, dielectric properties, Surface area to aspect ratio, quantum confinement size effects, bang gap effect at nanoscale. **(No. of lectures- 10)**

Synthesis of Nanomaterials - The principles of nucleation and growth, thermodynamics, kinetics, and mechanisms of Nucleation and Growth of nanocrystals, crystallography, surfaces and Interfaces, Applications to growth from solutions, melts and vapors.

(No. of lectures- 8)

Nano Fabrication - Introduction to micro/nano fabrication, photolithography, x-ray lithography, e-beam lithography, nanoimprint lithography, stamping techniques for micro/nano fabrication, methods and applications of lithographic techniques.

(No. of lectures- 9)

AFM based nanolithography, Dip-Pen Lithography (DPN) and nanomanipulation, self-assembly, template-based growth of nanorod arrays, 3D nanofabrication using focused ion beam (FIB), MEMS and NEMS, nano and micro-structured semiconductor materials for microelectronics.

(No. of lectures- 12)

TEXT/ REFERENCE BOOKS: -

1. The Physics and Chemistry of Nano Solids, Frank J. Owens and Charles P. Poole, Wiley- Interscience, 2008
2. Nanomaterials: An Introduction to Synthesis, Properties and Applications, Dieter Vollath, John Wiley and Sons, 2013
3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C. N. R. Rao, Achim Mller, A. K. Cheetham, John Wiley and Sons 2007
4. Fabrication Engineering at the Micro- and Nanoscale, Stephen A. Campbell, 4th Edition. Oxford University Press 2012
5. Microchip Fabrication, P. V. Zant, McGraw-Hill Education; 5th edition 2004
6. Enabling technology for MEMS and Nanodevices, H. Baltes et al, Wiley-VCH, 2008

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction and background
2.	Physical Properties of Nanomaterials
3.	Effect of size on thermal, electrical properties of nanoscale materials
4.	Effect of size on thermal, electrical properties of nanoscale materials
5.	mechanical properties of nanoscale materials
6.	optical properties of nanoscale materials
7.	magnetic properties of nanoscale materials
8.	diffusion properties, dielectric properties
9.	Surface area to aspect ratio, Quantum confinement size effects
10.	bang gap effect at nanoscale
11.	Synthesis of Nanomaterials overview
12.	The principles of nucleation and growth
13.	thermodynamics, kinetics, and mechanisms of Nucleation and Growth
14.	crystallography, surfaces and Interfaces
15.	crystallography, surfaces and Interfaces
16.	Applications to growth from solutions, melts and vapors
17.	Applications to growth from solutions, melts and vapors
18.	Applications to growth from solutions, melts and vapors
19.	Introduction to micro/nano fabrication
20.	photolithography
21.	x-ray lithography
22.	e-beam lithography
23.	nanoimprint lithography
24.	stamping techniques for micro/nano fabrication
25.	stamping techniques for micro/nano fabrication
26.	methods and applications of lithographic techniques
27.	methods and applications of lithographic techniques

28.	AFM based nanolithography
29.	Dip-Pen Lithography (DPN) and nanomanipulation
30.	Dip-Pen Lithography (DPN) and nanomanipulation
31.	self-assembly
32.	template-based growth of nanorod arrays
33.	3D nanofabrication using focused ion beam (FIB)
34.	MEMS and NEMS
35.	MEMS and NEMS
36.	nano and micro-structured semiconductor materials for microelectronics
37.	nano and micro-structured semiconductor materials for microelectronics
38.	Course revision
39.	Course revision

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
AE	24PHTXXX	Magnetic Memory Devices	3	3	1	0	0

PREREQUISITE – Condensed Matter Physics

COURSE OBJECTIVE(s)
Impart fundamentals knowledge to 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 magnetic recording, basics of magnetism, various forms of magnetic energies, hard and soft magnetic materials, magnetic anisotropies, exchange bias, spin relaxation mechanisms, concepts of spin detection and magnetic memory, magnetic domains and domain walls, single domain nano-particles. Materials for magnetic memory, thin magnetic films, particulate media, flexible media and rigid disk substrates, nanostructures for spin electronics. **(No. of lectures: 13)**

Fundamental recording theory, media magnetization, erasure and overwrite, recording zone and losses, play back theory, magnetic head circuits, magnetoresistance, anisotropic magnetoresistance (AMR), giant magnetoresistance (GMR) heads, tunneling magnetoresistance (TMR) heads, field from magnetic heads, perpendicular head fields, flux linkage, and leakage. **(No. of lectures: 14)**

High density data storage: MRAM, Savtchenko switching and toggle MRAM, ultra-high-density devices. Spin torque effect, current and spin transfer torque driven domain wall motion, race track memory, shift resistor, Q-bits and spin logic. **(No. of lectures: 12)**

TEXT/ REFERENCE BOOKS: -

1. Introduction to Magnetic Materials, B. D. Cullity and C. D. Grahm, Willey, 2009.
2. Magnetic Recording Technology, C.D. Mee and E.D. Daniel, McGraw-Hill Professional (1996).

3. Introduction to Spintronics, S. Bandyopadhyay, M. Cathay, CRC Press, 2008.
4. Ma gnetoelectronics, M. Johnson, Academic Press 2004.
5. The Physics of Ultra-high Density Magnetic Recording, Martin L. Plumer, Johannes Van Ek and D. Weller, Springer (2001).

Lecture Plan

Lecture No.	Topics to be covered
1.	Introduction to the course syllabus
2.	History and overview of magnetic recording
3.	basics of magnetism, various forms of magnetic energies
4.	hard and soft magnetic materials, magnetic anisotropies
5.	exchange bias, spin relaxation mechanisms
6.	concepts of spin detection and magnetic memory
7.	magnetic domains and domain walls, single domain nano-particles
8.	Materials for magnetic memory, thin magnetic films, particulate media
9.	flexible media and rigid disk substrates, nanostructures for spin electronics
10.	Fundamental recording theory
11.	media magnetization, erasure and overwrite
12.	recording zone and losses
13.	play back theory, magnetic head circuits
14.	magnetoresistance, anisotropic magnetoresistance (AMR)
15.	giant magnetoresistance (GMR) heads
16.	tunneling magnetoresistance (TMR) heads
17.	field from magnetic heads, perpendicular head fields
18.	flux linkage, and leakage
19.	High density data storage: MRAM
20.	Savtchenko switching and toggle MRAM
21.	ultra-high density devices.
22.	Spin torque effect,
23.	current and spin transfer torque driven domain wall motion
24.	race track memory
25.	shift resistors
26.	Q-bits and spin logic.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF PHYSICS

DETAILS OF THE COURSE

Course Type	Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
AE	24PHTXXX	Fundamentals of 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
d)	Internal assessment (based upon assignments, quizzes and attendance)	20%
e)	Mid-term examination	30%
f)	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. electrodes and active materials, carbon and related electrodes, transparent conducting electrodes, 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 and catalyst design. basics of the photocatalytic mechanisms of water and other related systems, energy level diagram, photochemical cell designs, fabrication and performance analysis

(No. of lectures: 16)

PV Working principle, device structure and assembly, broad classification of solar cells, important parameters in photovoltaics (describing J-V characteristics, spectral response-EQE & IQE), Shockley-Queisser limit, photon management), thin film solar cells: DSSC-oxides and dyes, pervoskites and tandem solar cells, fabrication processes, energy level diagrams, factors affecting the photovoltaic performance, exciton diffusion length, charge transport and band gap, typical characteristics and spectral response, technology limitations, comparison of the technologies. **(No. of lectures: 3)**

Capacitor & supercapacitor, concept of EDLC, electrodes and electrolytes for supercapacitors, fabrication processes, 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 other batteries, battery components and design of electrodes, cell and battery fabrication, measurements- CD curves, priming & cycling, time scales, energy and power densities, charge retention, long term stability, comparison of performance, building supercap packs, voltage and current management, hybrid battery-supercap device, electric mobility. **(No. of lectures: 16)**

Building block cells, battery modules and packs, voltage and current management, all solid-state batteries & new concepts in batteries beyond lithium, smart batteries; basic concepts of fuel-cells, types of fuel cells, fuels for fuel cell, catalysts, membranes fuel cell design. **(No. of lectures: 4)**

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
8	Hydrogen production technologies
9	Water splitting technologies for hydrogen and oxygen generation

10	Electrochemical water splitting; free energy adsorption, volcano plot, Basic reaction mechanism
11	Basics of the photocatalytic mechanisms of water and other related systems
12	Energy level diagram
13	Electrode design and electrode-electrolyte interface
14	Photochemical cell designs, Fabrication and performance analysis
15	Measurement modes: Cyclic voltammetry, Linear sweep voltammetry, Chronopotentiometry,
16	Impedance spectra, Tafel plot, Electrochemical cell design, Figures of merit.
17	PV Working principle, classification,
18	Shockley-Queisser limit, photon management
19	Thin Film Solar Cells
20	Typical characteristics and spectral response, Technology limitations, Comparison of the technologies
21	Capacitor & supercapacitor, Concept of EDLC
22	Pseudocapacitors
23	Electrodes and electrolytes for supercapacitors
24	Basic electrochemical concepts and definitions, Pseudo and asymmetric supercapacitors
25	Li-ion capacitors, comparison of performances and application areas
26	Fabrication processes
27	Primary and secondary batteries, Principle of operation
28	Conventional batteries, Li-ion and other batteries
29	Battery components and design of electrodes, cell and battery fabrication
30	Measurements- CD curves, priming & cycling, time scales, charge retention, coulombic efficiency, self-discharge & charge retention, long term stability
31	Ragone plot: energy and power densities, performance comparison
32	Introduction to Electrochemical Impedance Spectroscopy (EIS), Series and Parallel circuits, Nyquist plots

33	Hybrid battery-supercap device, electric mobility
34	Building block cells, battery and supercap modules and packs, Voltage and current management
35	All solid-state batteries & new concepts in Batteries beyond lithium
36	Basic concepts of fuel-cells
37	Types of fuel cells, Fuels for fuel cell
38	Catalysts, Membranes, Fuel cell design
39	Course review, resolving queries, and conclusion