

Progressive Education Society's
Modern College of Arts, Science and Commerce,
Shivajinagar, Pune - 5

First Year of M.Sc. Physics
(2023 Course under NEP 2020)

Course Code: 23ScPhyP111

**Course Name : Mathematical Methods
in Physics**

Teaching Scheme: TH: 5 Hours/Week

Examination Scheme: CIA : 50 Marks

Credit: 04

End-Sem : 50 Marks

Prerequisite Courses:

- Vector Algebra
- Vector Calculus
- Basics of Complex numbers
- Differential equations
- Differentiation and Integration

Course Objectives:

- To Study various mathematical concepts used in the study of Physics
- To learn application of mathematical methods in solving various equations in Physics and interpretation of the equations from Physics view point.

Course Outcomes:

On completion of the course, student will be able to–

- Understand the concepts/ equations involved in various areas of Physics like Electrodynamics, Quantum Mechanics, Classical Mechanics, Solid State Physics etc.
- Apply the methods to various situations and determine solutions of the problems.

Course Contents

Module 1	Elements of complex analysis	15 lectures
	●Cauchy- Riemann conditions ●Analytic functions ●Cauchy's theorems ●Poles and singularities ●Taylor and Laurent series ●Residues, Residue theorem ●Contour Integrals ●Experiential Learning	
Module 2	Matrices	15 lectures
	●Revision of vector Algebra ●Matrix representation, Eigen values and eigen vectors ●Inner product, Orthogonality and Orthonormality ●Self adjoint and Unitary transformations ●Eigen values and eigenvectors of Hermitian & Unitary transformations ●Experiential Learning	
Module 3	Special Functions	15 lectures
	●Legendre, Hermite, Laguerre function – Generating function ●Recurrence relations and their differential equations ●Orthogonality properties ●Bessels's function of first kind ●Spherical Bessel function ●Associated Legendre function ●Spherical harmonics ●Experiential Learning	
Module 4	Fourier series and Transform	15 lectures

	● Fourier series revision: Dirichlet conditions, Fourier series for Even and Odd functions, Fourier series of half range ● Complex form of Fourier Series ● Convergence, Fourier Integral ● Fourier Transform ● Parseval's identity ● Application to the solution of differential equations ● Laplace transform and its properties ● Experiential Learning	
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References:

1. Complex Variables and Applications : J.W.Brown, R. V. Churchill ,7th Edition, Mc-Graw Hill
2. Mathematics for Physical Sciences – Mary Boas, John Wiley & Sons
3. Linear Algebra – Seymour Lipschutz, Schaum Outlines Series- Mc-Graw Hill edition
4. Matrices and Tensors in Physics, A. W. Joshi, 3rd Edition, New Age International
5. Mathematical methods for Physicists – Arfken & Weber – 6th Edition-Academic Press- N.Y.
6. Fourier Series - Seymour Lipschutz, Schaum Outlines Series
7. Fourier Series and Boundary value problems - R. V. Churchill, McGraw Hill

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First Year of M.Sc. Physics
(2023 Course under NEP 2020)

Course Code: 23ScPhyP112

Course Name: Classical Mechanics

Teaching Scheme: TH: 5 Hours/Week

Credit: 04

Examination Scheme: CIA : 50 Marks

End-Sem : 50 Marks

Prerequisite Courses:

- Basic Mathematical Methods
- Newtonian Mechanics

Course Objectives:

- To Study Lagrangian and Hamiltonian Dynamics
- To Study Non-inertial frames.

- To apply the theory into relevant numericals and solve them.

Course Outcomes:

On completion of the course, student will be able to–

- Understand and apply the Lagrangian and Hamiltonian dynamics to different systems.
- Apply the concepts of Inertial and Non-Inertial frames of reference and use in case studies

Course Contents

Module 1	Constrained Motion and Lagrangian formulation	15 lectures
	● Constraints and their types ● Generalized coordinates ● Lagrange's equations of motion including velocity dependent potentials ● Properties of kinetic energy function ● Theorem on total energy ● Generalized momenta, cyclic-coordinates ● Integrals of motion ● Jacobi integrals and energy conservation ● Concept of symmetry ● Invariance under Galilean transformation	
Module 2	Variational Principle and Hamilton's formulation	15 lectures
	● Variational principle ● Euler's equation ● Applications of variational principle, shortest distance problem, Brachistochrone, Geodesics of a Sphere ● Hamilton's function and Hamilton's equation of motion ● Configuration space, phase space and state space ● Lagrangian and Hamiltonian of relativistic particles ● Canonical Transformation	
Module 3	Poisson Brackets, Small Oscillations and Rigid Body Dynamics	15 lectures
	● Poisson Brackets: Definition, Identities, Poisson theorem, Jacobi-Poisson theorem, Jacobi identity, (statement only), invariance of PB under canonical transformation, ● Small Oscillations : Normal modes and coordinates. Coupled Oscillators ● Rigid body Dynamics : Generalized Coordinates, Angular Momentum and Moment of Inertia, Euler's Equations ● Rigid body Dynamics : Generalized Coordinates, Angular Momentum and Moment of Inertia, Euler's Equations	
Module 4	Non-inertial frames of References, Central Forces	15 lectures

	● Rotating frames of reference ● Inertial forces in rotating frames ● Foucault's pendulum. ● Two body central force problem, stability of orbits ● Condition for closure ● Integrable power laws, Kepler's problems ● Orbits of artificial satellites ● Virial theorem	
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References:

1. Classical Mechanics by N.C.Rana and P.S.Joag, Tata Mc-Graw Hill Publishing Company Limited,
2. Classical Mechanics by J.C.Upadhyaya, Himalaya Publishing House.
3. Classical Mechanics by H.Goldstein, Narosa Publishing Home,, New Delhi.
4. Classical Dynamics of Particles and Systems by Marion and Thomtron, Third Edition, Horoloma Book Jovanovich College Publisher.
5. Introduction to Classical Mechanics by R.G.Takwale and P.S.Puranik, Tata Mc- Graw Hill Publishing Company Limited

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First Year of M.Sc. Physics
(2023 Course under NEP 2020)

Course Code : 23ScPhyP113

Course Name : Quantum Mechanics - I

Teaching Scheme: TH: 5 Hours/Week

Credit: 04

Examination Scheme: CIA : 50 Marks

End-Sem : 50 Marks

Prerequisite Courses:

- Basic mathematical methods
- Classical Mechanics
- Solution of Differential Equations

Course Objectives:

- To learn the Schrodinger and Dirac Approach to Quantum Mechanics
- To apply the theory into relevant numerical examples and solve them

Course Outcomes:

On completion of the course, student will be able to–

- Use the concepts of Quantum Mechanics and apply them.
- Solve numerical examples using the concepts of Quantum Mechanics

Course Content

Module 1	Linear vector space	15 lectures
	● Dirac notation and representation of state spaces ● Concept of Kets, Bras and Operators ● Expectation values, superposition principle, orthogonality, completeness theorem ● Commutation and compatibility ● Change of basis, Unitary operators ● Representation of state vectors	
Module 2	Schrodinger Formalism	15 lectures
	● Schrodinger equation and probability interpretation ● Particle in one-dimensional potential well (finite and infinite depth) and its energy states ● Linear harmonic oscillator ● Free particle wave function, angular momentum, Hydrogen atom, expression of Bohr radius.	
Module 3	Angular Momentum	15 lectures
	● Eigen values and eigen functions of L^2 and L_z operators ● Ladder operators L_+ and L_- ● Matrix representation of J in $j m\rangle$ basis. ● Addition of angular momenta, Computation of Clebsch-Gordon coefficients in simple cases ($j_1 = \frac{1}{2}$, $j_2 = \frac{1}{2}$)	
Module 4	Approximation methods	15 lectures
	● Time-independent perturbation theory for non-degenerate and degenerate states, Applications ● Anharmonic oscillator ● Helium atom, Stark effect in hydrogen atom ● Variational methods	

References:

1. A Text-book of Quantum Mechanics : P.M.Mathews and K.Venkatesan.
2. Quantum mechanics :A. Ghatak and S. Lokanathan
3. Quantum Mechanics by L.I. Schiff
4. Modern Quantum mechanics: J. J.Sakurai
5. Quantum Physics: R. Eisberg and R.Resnick
6. Introduction to Quantum Mechanics: David J.Griffiths
7. Introductory Quantum mechanics: Granier, Springer Publication.
8. Introductory Quantum Mechanics: Li boff, 4th Edition, Pearson Education Ltd
9. Quantum Mechanics: Nouredine Zettili, , A John Wiley and Sons, Ltd., Publication
10. Principles of Quantum Mechanics: Shankar R. , IInd Edition (Plenum, 1994)

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First Year of M.Sc. Physics
(2023 Course under NEP 2020)

Course Code : 23ScPhyP114

Course Name : Physics General Lab - I

Teaching Scheme: TH: 5 Hours/Week

Credit: 04

Examination Scheme: CIA : 50 Marks

End-Sem : 50 Marks

Prerequisite Courses:

- Modern Physics
- Electronics
- Basic Material Science

Course Objectives:

- To apply the theory studied to practice

Course Outcomes:

On completion of the course, student will be able to–

- Have hands-on experience of the theory course through its applications.
- determine the issues and resolve the issues during the experiment

Course Contents:

	List of Experiments	
	1. DAC (R-2R for 4-bit). 2. Active filter- Low pass and High pass using op-amp 3. Function generator using OP-AMP. 4. Study of Multiplexer and Demultiplexer/ Study of Sample and Hold circuit. 5. Study of voltage controlled oscillator using IC-566. 6. Study of Crystal oscillator. 7. Diode pump staircase generator 8. Pulse train generator using IC 555. 9. CVCC power supply 10. Magnetic susceptibility measurement using Gouy's Method 11. Study of Hall Voltage as a function of probe current and magnetic field and determination of Hall Coefficient and carrier concentration in given sample. 12. Estimate the diameter of cylindrical wire using He-Ne laser 13. Counters 14. Estimation of Band gap using four probe method 15. Simulation using multisim	

Reference Books:

1. Experimental Physics: Worsnop and Flint.
2. Practical Physics, D.R. Behekar, Dr.S. T. Seman, V.M.Gokhale,P.G.Kale (Kitab Mahal Publication)
3. Solid State Laboratory Manual in Physics, Department of Physics, University of Pune, Pune-7. (1977)

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First Year of M.Sc. Physics
(2023 Course under NEP 2020)

Course Code : 23ScPhyP121

Course Name : Electronics

Teaching Scheme: TH: 5 Hours/Week
Examination Scheme: CIA : 50 Marks

Credit: 04
End-Sem : 50 Marks

Prerequisite Courses:

- Basics of electronics including semiconductor diodes
- Different types of diodes

Course Objectives:

- To Study working of op-amp and its various characteristics and applications
- To learn how to design a circuit using op-amp

Course Outcomes:

On completion of the course, student will be able to–

- design circuits based on op-amp
- apply knowledge to resolve the issues with the circuits

Course Content

Module 1	Study of op-amp and oscillators	15 lectures
	● Operational amplifier revision ● Operational amplifier as adder, subtractor, integrator and differentiator, comparator, Schmitt trigger and logarithmic amplifier ● Oscillators- principle, types, Barkhausen criterion ● Tank circuit, Colpitts oscillator, Hartley Oscillator, ● Phase shift oscillator, Wien bridge oscillator, Triangular, Saw-tooth wave generator, voltage controlled oscillator	
Module 2	Special Applications	15 lectures
	● Comparator , characteristics, clippers and clampers, peak detector, sample and hold circuit ● The 555 timer, monostable, astable operation of the 555 timer. ● phase locked loops, power amplifiers - principles ● voltage regulators	
Module 3	Sequential Circuits	15 lectures
	● Flip Flops: RS flip flop using NAND/NOR, clocked RS, D, JK, and T flip flops, Preset and clear inputs ● Counters: 4-bit Asynchronous counter, Up-Down counter, Synchronous 4-bit counter ● Shift Registers: • Types of registers: SISO, SIPO, PISO, PIPO ● Applications of counter and register	
Module 4	Data Converters	15 lectures

	● Digital to analog converters Weighted resistive network R-2R ladder network, D/A accuracy and resolution ● Analog to Digital converters: Simultaneous conversion Counter method Tracking (Continuous) method, ● Successive approximation method Single slope, Dual slope method A/D accuracy and resolution	
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References:

- 1) OPAMPS and Linear Integrated Circuits: Ramakant Gayakwad, Prentice Hall
- 2) Principles of electronics: V.K.Mehta
- 3) Electronic Principles: A. P. Malvino

Progressive Education Society's
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First Year of M.Sc. Physics
(2023 Course under NEP 2020)

Course Code : 23ScPhyP2101

Course Name : Electrodynamics - I

Teaching Scheme: TH: 5 Hours/Week
Examination Scheme: CIA : 50 Marks

Credit: 04
End-Sem : 50 Marks

Prerequisite Courses:

- Vector Analysis
- Ordinary Differential Equations
- Basic Electricity and Magnetism

Course Objectives:

- To Study the laws of Electric and Magnetic Theory
- To study the behavior of fields in material media.
- To apply the theory into relevant numericals and solve them.
- To learn the concept of relativity

Course Outcomes:

On completion of the course, student will be able to –

- Apply the concepts of Electrodynamics and use in case studies
- Solve numerical examples using the concepts of Electrodynamics

Course Contents

Module 1	Electrostatics	15 lectures
	● Introduction to electric field : Coulomb's Law and its application (discrete and continuous charge distribution), Gauss's Law and its application ● Electric field lines and electric flux ● Divergence and curl of electrostatic field ● Poisson's and Laplace's equation	

	● Scalar and vector potentials and Electrostatic potential energy ● Maxwell's displacement current. ● Maxwell's equations differential and integral form ● Conductors : basic properties of induced charges and surface charge distribution	
Module 2	Special techniques	15 lectures
	● Laplace's equations in one, two and three dimensions. ● Boundary value problem ● Method of electric images ● separation of variables ● Multipole expansion and Green's Function	
Module 3	Electric field in matter and Electromagnetics	15 lectures
	● Dielectrics : Concept ● Polarization ● Linear dielectric materials, ● Boundary conditions at the interface of two dielectrics ● Energy relations in quasi-stationary current systems ● Magnetic interaction between two current loops, Energy stored in electric and magnetic fields ● Poynting's theorem, General expression for electromagnetic energy	
Module 4	Magnetostatics	15 lectures
	● Lorentz force, Biot-Savart's Law, Magnetic field and Forces ● Divergence and curl on magnetic field, Ampere's law and its application ● Comparative study of electrostatics and magnetostatics. ● Magnetic vector potential ● Magnetization : Diamagnetization, paramagnetization and ferromagnetization ● Magnetic dipole and Magnetic field inside a matter. ● Magnetic susceptibility and permeability	

References:

1. Introduction to Electrodynamics, (3rd Edition) by David J. Griffith, Prentice-Hall of India, New Delhi
2. Introduction to Electrodynamics, by A.Z. Capri and P.V. Panat, Narosa Publishing House
3. Classical Electricity and Magnetism, by Panofsky and Phillips, Addison Wesley
4. Foundations of Electromagnetic Theory by Reitz and Milford, World Student Series Edition 5. Classical Electrodynamics, by J.D. Jackson, 3rd Edition John Wiley
6. Electromagnetic Theory and Electrodynamics, by Satya Prakash, Kedar Nath and Co., Meerut
8. Electromagnetics by B.B. Laud, Wiley Eastern
9. Electrodynamics by Kumar Gupta and Singh

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First Year of M.Sc. (Physics)
(2023 Course under NEP 2020)
Course Code : 23ScPhyP2102 Course Name : Statistical Mechanics

Teaching Scheme: TH: 5 Hours/Week

Credit: 04

Examination Scheme: CIA : 50 Marks

End-Sem : 50 Marks

Prerequisite Courses:

- Laws of Thermodynamics
- Maxwell relations
- Concept of ensemble

Course Objectives:

- To study thermodynamics of particles from a statistical point of view.
- To study applications of statistical mechanics in physics.

Course Outcomes:

On completion of the course, student will be able to–

- to understand different concepts and applications of statistical mechanics in physics

Course Contents

Module 1	Statistical Description and Thermodynamics of Particles	15 lectures
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	● Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble ● Postulate of equal a priori probability, Probability calculations ● Behavior of density of states, Liouville's theorem (Classical), Equilibrium conditions and constraints ● Distribution of energy between systems in equilibrium, Approach to thermal equilibrium ● Sharpness of the probability distribution ● Dependence of the density of states on the external parameters ● Equilibrium between interacting systems, Thermodynamical laws and basic statistical relations	
Module 2	Classical Statistical Mechanics	15 lectures
	● Micro-canonical ensemble, System in contact with heat reservoir ● Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics ● Grand-canonical ensemble, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function	
Module 3	Applications of Statistical Mechanics and Quantum Distribution Functions	15 lectures
	● Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal monoatomic gas, Gibbs paradox ● Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid, Maxwell velocity distribution, Related distributions and mean values ● Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, Evaluation of the partition function ● Partition function for diatomic molecules, Equation of state for an ideal gas, quantum mechanical paramagnetic susceptibility	
Module 4	Ideal Bose and Fermi Systems	15 lectures

	● Photon gas – i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity ● Einstein derivation of Planck's law, Bose-Einstein Condensation, Specific heat ● Photon gas – Einstein and Debye's model of solids ● Fermi energy, Mean energy of fermions at absolute zero, Fermi energy as a function of temperature, Electronic specific heat ● Introduction to Ising model	
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References:

- 1) Fundamentals of Statistical and Thermal Physics: F.Reif, McGraw Hill International Edition
- 1) Fundamentals of Statistical Mechanics: B.B. Laud, New Age International Publication
- 2) Statistical Mechanics: R.K. Pathria, Butterworth Heinemann (2nd Edition)
- 3) Statistical Mechanics: K. Huang, John Wiley and Sons (2nd Edition)
- 4) Statistical Mechanics: Satya Prakash and Kedar Nath Ram, Nath Publication
- 5) Statistical Mechanics: Lokanathan and Gambhir

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First Year of M.Sc. Physics
(2023 Course under NEP 2020)
Course Code : 23ScPhyP2103 Course Name: Atomic and Molecular Physics

Teaching Scheme: TH: 5 Hours/Week

Credit: 04

Examination Scheme: CIA: 50 Marks

End-Sem: 50 Marks

Prerequisite Courses:

- Fundamentals of atoms and molecules
- Atomic models and theories

Course Objectives:

- To study origin of spectrum in one electron and two electron systems
- To study molecules, molecular energy levels and molecular spectra
- To learn principles of various spectroscopic techniques and analysis methods

Course Outcomes:

On completion of the course, student will be able to–

- Understand various molecular bonds
- Understand origin of spectrum in atoms and molecules
- Understand and apply various spectroscopic techniques and analysis methods in research

Course Contents

Module 1	Study of atoms	15 lectures
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	● Revision: Atomic models, Hydrogen atom, quantum numbers, exclusion principle, electron configuration, Hund's rule ● Spectral lines, coupling scheme ● Fine structure and hyperfine structure ● Atoms in Electromagnetic field: Zeeman effect-Normal and Anomalous, Paschen- Back effect, Stark effect (weak field) ● Numericals	
Module 2	Study of molecules	15 lectures
	● Bonding mechanism in molecules ● Rotational and vibrational spectra for diatomic molecules ● Vibration course structure, vibrational analysis of band system ● Frank – Condon principle ● Electronic angular momentum in diatomic molecules	
Module 3	Spectroscopic techniques	15 lectures
	● Microwave Spectroscopy: microwave spectrometer, information derived from rotational spectra and analysis of microwave absorption by H₂O ● Infrared spectroscopy: IR spectrophotometer and instrumentation, sample handling techniques, FTIR spectroscopy and analysis of HCl spectrum, applications ● Raman spectroscopy: Theory of Raman scattering, Rotational Raman spectra, Mutual exclusion, Raman spectrometer, sample handling techniques, Fourier transform Raman spectrometer, Structure determination using IR and Raman spectroscopy (diamond), Applications ● Numericals	
Module 4	Resonance spectroscopy	15 lectures
	● ESR- Principles of ESR, ESR spectrometer, total Hamiltonian, hyperfine structure ● NMR – Magnetic properties of nucleus, resonance condition, NMR instrumentation, relaxation process, chemical shift, applications of NMR ● Numericals	

References:

- 1) Fundamentals of Molecular spectroscopy. Collin N. Banwell and Elaine M. McCASH
- 2) Molecular structure and Spectroscopy G. Aruldas.
- 3) Quantum Physics – Robert Eisberg and Robert Resnik
- 4) Introduction to solid states Physics - Charles, Kittel 7th Edition
- 5) Solid States Physics – A.J. Dekkar

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First Year of M.Sc. Physics
(2023 Course under NEP 2020)
Course Code : 23ScPhyP2104 Course Name: Physics General
Laboratory - II

Teaching Scheme: TH: 5 Hours/Week

Credit: 04

Examination Scheme: CIA: 50 Marks

End-Sem: 50 Marks

Prerequisite Courses:

- Modern Physics
- Solid state physics and Thermodynamics
- Basic Material Science

Course Objectives:

- To apply the theory studied to practice
- To learn different synthesis and deposition methods

Course Outcomes:

On completion of the course, student will be able to–

- Deposit thin films with different methods
- Have hands-on experience of the theory course through its applications.

Course Contents:

	Lab Course-II	
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	1) Skin depth in Al using electromagnetic radiation 2) Franck – Hertz Experiment. 3) Inter-relationship between Resistivity and Temperature of a given specimen 4) Electron Spin Resonance (ESR) 5) Michelson Interferometer 6) Film deposition by Chemical bath deposition method. 7) Determination of crystallite size from XRD data. 8) Estimation of bandgap using Toc plot from UV-VIS data 9) Estimation of average particle size using SEM/FESEM data. 10) FTIR analysis of given Specimen 11) Raman analysis of given Specimen 12) Thin film deposition by Electrochemical deposition method. 13) Counting statistics, G.M. tube. 14) Analysis of thickness of thin films using Gravimetric method 15) Study of Effect of synthesis parameters on particle size.	
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Reference Books:

1. Experimental Physics: Worsnop and Flint.
2. Practical Physics, D.R. Behekar, Dr.S. T. Seman, V.M.Gokhale,P.G.Kale (Kitab Mahal Publication)
3. Solid State Laboratory Manual in Physics, Department of Physics, University of Pune, Pune-7. (1977)
4. Nanotechnology: Principles & Practices. Sulbha K. Kulkarni, Capital Pub
5. Handbook of Thin Film Technology: Maissel and Glang, (Mc Graw Hill)

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First Year of M.Sc.
(2023 Course under NEP 2020)
Course Code : 23ScPhyP2201 **Course Name: Material Science**

Teaching Scheme: TH: 5 Hours/Week

Credit: 04

Examination Scheme: CIA: 50 Marks

End-Sem: 50 Marks

Prerequisite Courses:

- Fundamentals of Atomic and Molecular structures
- Solid state physics and Thermodynamics

Course Objectives:

- To study Basics of materials processes.
- To study phase diagrams for different materials.

Course Outcomes:

On completion of the course, student will be able to–

- Understand the important processes like diffusion in solids
- Understand the Phase diagrams and apply it for various industrial processes

Course Contents:

Unit 1	Basics of Materials science and Solid Solutions	15 lectures
	● Revision of atomic bonding ● Defects in solids ● Solid solubility, Types of solid solutions – Substitutional and Interstitial ● Factors governing solid solubility (Hume - Rothery rule), Atomic size and ● size factor in solid solutions ● Vegard's law	
Unit 2	Diffusion in Solids	15 lectures
	● Mechanism of Diffusion	

	● Fick's first laws of diffusion ● Fick's second laws of diffusion ● Factors governing diffusion ● Experimental determination of D ● Applications of diffusion: Corrosion resistance of duralumin, Decarburization of steel, Doping of semiconductors	
Unit 3	Metallurgical Thermodynamics	15 lectures
	● Revision of laws of thermodynamics, ● measurement of changes in enthalpy and entropy ● Richard's rule, Trouton's rule ● Chemical reaction equilibrium, ● Thermodynamic properties of solutions (mixing processes – Rault's law, activity coefficient; regular solution behavior – Henry's law) ● Gibb's phase rule	
Unit 4	Phase Diagrams	15 lectures
	● Thermodynamic origin of phase diagrams ● Lever rule ● Type I phase diagram ● Type II phase diagram ● Type III phase diagram ● Maxima and minima in two-phase regions, Miscibility gaps ● Topology of binary phase	

Reference Books:

1. Elements of Materials Science and Engineering (5th edition) - Lawrence H. Van Vlack, Addison - Wesley Publishing Co.
2. Materials Science and Engineering - V. Raghvan
3. Physical Metallurgy (Vol-I) R.W.Cahn and P.Hassen, North Holland Physics Publishing, New York
4. Introduction to Materials Science for Engineers (6th edition) - J.F.Shaekelford and M.K.Murlidhara - Pearson Education
5. Materials Science – Kodgire and Kodgire