Teaching and Examination scheme of SEM PG SEM III and IV

2023-24

INSTITUTE OF SCIENCE, NAGPUR
(An Autonomous Institute of Government of Maharashtra)

DEPARTMENT OF PHYSICS

Teaching and Examination scheme
Name of Course (Subject): PHYSICS
Programme Outcomes (PO):

On completion of the M.Sc. PHYSICS students will be able to:

1. Develop Understanding of advanced concepts of physics
2. Solve the problems in physics.
3. Demonstrate the concepts of physics by performing experiments.
4. Understand multi-scale phenomena of physics at the smallest (10^{-15} m) to the largest scale (10^{26}m)
5. Develop algorithm using programming techniques for numerically solving physics problems.
6. Design and find solutions to innovative problems based on physics.
7. Pursue advanced studies and research in physical sciences.

M.Sc. Sem- III (Physics Major Subject)

Level 6.5

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Pract		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
				Th	Tu	P					
1	DSC	Paper 1:- Quantum Mechanics -II	M-PH631T	4	--	--	4	3	80	20	40
		Paper 2:- Solid State Physics	M-PH632T	4	--	--	4	3	80	20	40
		DSC Lab	M-PH633P	--	--	12	6	6	100	50	75
2	DSE	1. Atomic And Molecular Spectroscopy 2. Nuclear Physics-I	M-PH634T	4	--	--	4	3	80	20	40
3	RP	Research Project /Dissertation (Core)	M-PH635P	--	--	8	4	--	50	50	50
				12	**--**	**20**	**22**		**390**	**160**	**-**

M.Sc. Sem- IV (Physics Major Subject)

Level 6.5

Sr No	Course Category	Name of the course (Title of the Paper)	Course code	Teaching Scheme (hrs)			Total Credit	Evaluation Scheme			
				Theory	Tut	Prac		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
				Th	Tu	P					
1	DSC	Statistical Physics	M-PH641T	4	--	--	4	3	80	20	40
		Electrodynamics	M-PH642T	4	--	--	4	3	80	20	40
		DSC Lab	M-PH643P	--	--	8	4	4-6	80	20	50
2	DSE	1. Material Science 2. Nuclear Physics-II	M-PH644T	4	--	--	4	3	80	20	40
3	RP	Research Project /Dissertation (Core)	M-PH645P	--	--	12	6	--	75	75	75
				12	**--**	**20**	**22**		**395**	**155**	**-**

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Table showing total marks in theory and Practical semester wise

Semester	Theory	Practical	Total Marks
I	420	130	550
II	420	130	550
III	390	160	550
IV	395	155	550
Total	**1625**	**575**	**2200**

Total Credits: Cumulative
Cumulative Credits required for PG in Major Subject (One Year PG Degree) = 44

Cumulative Credits required for PG in Major Subject (Two Year PG Degree) = 88

Abbreviations: On Job Training (Internship/Apprenticeship): OJT, Research Methodology: RM, Research Project: RP

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

DSC: **M-PH631T**

QUANTUM MECHANICS- II

PAPER- I

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

OBJECTIVES:

1. To disseminate the concepts of quantum mechanics with respect perturbation, variational WKB techniques
2. To disseminate the fundamental knowledge of identical particles and scattering
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of respect perturbation, variational WKB techniques
2. They the fundamental knowledge of identical particles and scattering
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Time independent perturbation theory, first order perturbation theory applied to nondegenerate states, second order perturbation extension to degenerate state, Application of perturbation theory to the ground state energy, He atom (calculation given in Pauling and Wilson), Normal and anomalous Zeeman effect, First order Stark effect in the ground and first excited states of H atom and second order Stark effect of H atom, an-harmonic oscillator.

Unit II **15 hrs.**

Time dependent perturbation theory, transition rate, Fermi Golden rule, constant perturbation harmonic in time, radiative transitions, absorption, and induced emission, atomic radiation, dipole approximation, Einstein's atomic radiation, Einstein's A and B coefficients and their calculations. Approximation methods: W. K. B. method and its application to barrier penetration. Variational principle and its application to simple cases like ground state of He atom and deuteron in Yukawa potential.

Unit III **15 hrs.**

System of identical particles, exchange and transposition operators, totally symmetric and antisymmetric wave function and their expressions for a system of non-interacting particles, statistics of systems of identical particles, Relation of statistics with spin, Ortho and para states of the helium atom and their perturbation by Coulomb repulsion. Hamiltonian of a molecule, Born-Oppenheimer approximation, outline of Heitler-London theory of the hydrogen molecule. Scattering theory, scattering cross-section in laboratory and centre of mass system, scattering by a central potential, Partial wave method, phase shifts and their importance, scattering by a square well potential and a perfectly rigid sphere, resonance scattering.

Unit IV **15 hrs.**

Relativistic wave equation, the Klein-Gordon equation, and initial difficulties in interpreting its solutions, Dirac's relativistic equation, Dirac's matrices, explanation of the spin of the electron, equation for an electron in an electromagnetic field and explanation of the magnetic moment due to the electron spin, spin-orbit interaction, solution for hydrogen atom in Dirac's theory, negative energy states and their qualitative explanations.

References:

1. E. Merzbacher, Quantum Mechanics (Wiley and Sons-Toppon)
2. J. L. Powell and B. Crasemann, Quantum mechanics (B I Publications)
3. L. I. Schiff, Quantum Mechanics (McGraw-Hill)
4. Quantum Mechanics: Aruldhas
5. Pauling and Wilson, Introduction to Quantum Mechanics
6. A.K. Ghatak and Lokanathan, Quantum Mechanics (Macmillan, India)
7. Quantum Mechanics: 500 problems with Solutions: Aruldhas (PHI)

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

DSC: **M-PH632T**

SOLID STATE PHYSICS

PAPER- II

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

OBJECTIVES:

1. To disseminate the concepts of solid state physics
2. To disseminate the fundamental knowledge of 1D, 3D crystal lattice and various phenomenon in solids
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students gain knowledge of concepts of solid state physics
2. They the fundamental knowledge of 1D, 3D crystal lattice and various phenomenon in solids
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

UNIT I: Density of states, k-space, Origin of energy gap, Bloch theorem, Kronig- Penney model, Construction of Brillouin zones, Extended and reduced zone schemes, Effective mass of an electron, Tight binding approximation, Magnetism: Quantum theory of paramagnetism, Magnetism of iron group and rare earth ions, Exchange interactions, Pauli paramagnetic susceptibility.

UNIT II: Concept of lattice mode of vibration, phase velocity, group velocity of harmonic waves, Harmonic approximation, Lattice vibrations of linear monoatomic chain, Lattice vibrations of linear diatomic chain, Dispersion relations, Acoustic and optical phonons, Theories of lattice specific heat: Einstein model and Debye model, Born procedure, anharmonicity and thermal expansion.

UNIT III: Electron moving in 1-D and 3-D potential wells, Quantum state and degerneracy, Electrical conductivity of metals, Thermal conductivity of metals, Relaxation time and mean free path, electrical resistivity of metals, Free carrier concentration in semiconductors, Fermi level and carrier concentration in semiconductors, Effect of temperature on mobility and electrical conductivity of semiconductor, Hall effect in conductors and semiconductors.

UNIT IV: Phenomenon of Superconductivity, Type I and Type II superconductors, Meissener effect, isotope effect, London equations, London penetration depth, Coherence length, Two fluid model of superconductivity, Elements of BCS theory, Tunnelling, DC Josephson effect, AC Josephson effect, SQUID, High TC superconductors (elementary)

References:

1. Solid State Physics, Charles Kittel, John Willey & Sons
2. Materials Science and Engineering: V. Raghavan
3. Solid State Physics: S. O. Pillai (New Age International 2006)
4. Solid State Physics, by Abdul Ali Omar, Pearson Publication, Delhi
5. Solid State Physics, by Saxena, Gupta, Mandal, Pragati prakashan
6. Introduction to solids by Azaroff, Wiley publication
7. Solid state physics by Singhal

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

DSC: **M-PH633P**

PRACTICALS

Marks- 100 (Credit 4, 4h/week)

1. Study of Crystals
2. Determination of metallic element in a given inorganic salt.
3. Study of line spectra
4. Crystal structure determination by powder diffraction.
5. Study of microstructures of metal alloys.
6. Dislocation in alkali halide crystals.
7. Crystal growth from slow cooling of the melt.
8. Thermal analysis of binary alloy.
9. Study of line spectra on photographed plates/films and calculation of plate factor.
10. Verification of Hartman's dispersion formula.
11. Study of sharp and diffuse series of potassium atom and calculation of spin orbit interaction constant.
12. To record the spectrum of CN violet bands and to perform vibrational analysis.
13. To record the visible bands of ALO and to perform vibrational analysis.
14. To photograph and analyse the reddish glow discharge in air under moderate pressure.
15. To photograph and analyse the whitish glow discharge in air under reduced pressure.
16. To perform vibrational analysis of a band system of N2.
17. To perform vibrational analysis of band system of C2
18. To photograph and analyse the line spectrum of Calcium atom.
19. To record/analyse the fluorescence spectrum of a sample.
20. To record/analyse the Raman spectrum of a sample.
21. Study of Hyperfine structure of the green line of mercury.
22. To photograph the (O, O) band of CuH and to perform rotational analysis.
23. Experiments on Prism/Grating Spectrometer.
24. Wavelength of laser light.
25. Faraday effect with laser.
26. Michelson interferometer.
27. Analysis of ESR Spectra of transition metals.
28. Analysis of H-atom spectra in minerals.
29. Measurements of dielectric constant of polymer sheet at low frequency.
30. To measure the dielectric constant and polarisation of unknown liquid.
31. To measure the dielectric constant of unknown wood at microwave frequency
32. To measure the ultrasonic velocity in unknown liquid.
33. Diffraction by He-Ne Laser
34. To study polarization of sodium light

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

DSE: **M-PH634T**

Atomic and Molecular Spectroscopy

PAPER- III

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of atomic spectra like electron spin, helium and alkali spectra NMR spectra
2. To disseminate the fundamentals of rotational and vibrational and electronic spectra
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain deep knowledge of atomic spectra like electron spin, helium and alkali spectra NMR spectra
2. They gain knowledge of rotational and vibrational and electronic spectra
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

Unit-I **15 hrs.**

Quantum states of an electron in an atomic Electron spin, spectrum of hydrogen, Helium and alkali atoms, Relativistic corrections for energy levels of hydrogen; Basic principles of interaction of spin and applied magnetic field. Concepts of NMR spectroscopy concepts of spin-spin and spin-lattice relaxation, chemical shift; spin-spin coupling between two and more nuclei; chemical analysis using NMR. Mossbauer effect-Recoil less emission of gamma rays, chemical shift, magnetic hyperfine interaction

Unit II **15 hrs.**

Electron spin resonance, experimental setup, hyperfine structure and isotopic shift, width of spectral lines, LS & JJ coupling, Zeeman, Paschen Back & Stark effect. Spontaneous and Stimulated emission, Einstein A & B Coefficients; LASERS, optical pumping, population inversion, rate equation, modes of resonators and coherence length, Role of resonant cavity, three and four level systems, Ammonia MASER, ruby, He-Ne, CO2, dye and diode lasers, Lasers applications

Unit III **15 hrs.**

Rotational, vibrational and Raman spectra of diatomic molecules, Quantum theory, Molecular polarizability, Intensity alteration in Raman spectra of diatomic molecules, Experimental setup for Raman spectroscopy in the structure determination of simple molecules. polyatomic molecules, symmetric top asymmetric top molecules. Hunds rule.

Unit IV **15 hrs.**

Electronic spectra of diatomic molecules, Born Oppenheimer approximation, Vibrational Coarse structure of electronic bands, intensity of electronic bonds, Franck Condon principle, and selection rules, dissociation and pre dissociation, dissociation energy, rotational fine structure of electronic bands. General treatment of molecular orbitals, Hund’s coupling cases.

References:

1. Molecular Spectroscopy: - Jeane L. McHale.
2. Mossbauer spectroscopy –M. R. Bhide.
3. NMR and Chemistry – J. W. Akitt.

4. Structural Methods in inorganic chemistry, E.A V.Ebsworth, D. W. H.Rankin, S.Crdock.
5. Introduction to Atomic Spectra – H. E. White.
6. Fundamental of Molecular Spectroscopy – C. B. Banwell.
7. Spectroscopy Vol. I, II and III, Walker and Straghen.
8. Introduction to Molecular Spectroscopy – G. M. Barrow.
9. Spectra of diatomic molecules – Herzberg.
10. Molecular spectroscopy – Jeanne L. McHale.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

DSE: **M-PH634T**

Nuclear Physics-I

PAPER- III

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

OBJECTIVES:

1. To disseminate the knowledge of nuclear properties, decay processes and nuclear detectors
2. To disseminate the fundamental knowledge of particle accelerators
3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain knowledge of nuclear properties, decay processes, elementary particles
2. They gain knowledge of particles counters
3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

UNIT-I: Basic nuclear properties **7.5 hrs**

Nuclear mass, Nuclear size : Nuclear Radius & its determination by Rutherford scattering, electron scattering & mirror nuclei method. Nuclear dipole moment and electric quadruple moment. Nuclear Binding, average binding energy and its variation with mass number, Semi empirical mass formula. Nature of nuclear force, Deuteron problem.

UNIT -II: Nuclear Models **7.5 Hrs**

Nuclear models: Fermi gas model, Liquid drop model-assumptions, achievements, Bohr Wheeler theory of fission, Failure and limitations of liquid drop model, Shell model-nuclear magic numbers, experimental evidences of magic numbers, significance, achievements and limitations, magnetic moment and Schmidt lines.

UNIT II: Nuclear Detectors **7.5 hrs**

Nuclear Detectors: Ionization chamber, Proportional counter, Geiger Muller counter, Scintillation detector, Semiconductor Detector, Regions of multiplicative operations.

UNIT IV: Nuclear Accelerators **7.5 Hrs**

Classificaqtion of nuclear accelerators, and it's applications in various fields, Cyclotron, Synchrotron, Betatron, Linear accelerator, Van-de- Graaff generator, Light Hydron Collidor (LHC), Accelerators in India.

Reference Books:

1. Nuclear Physics, D.C.Tayal,(Himalaya Publishing House, Mumbai)
2. Introduction to Elementary Particles, D. Griffiths, 2nd Ed., Academic Press, 2008.
3. Introductory Nuclear Physics, S.S.M. Wong, 2nd Ed., Wiley VCH, 2004
4. Nuclear Physics, Kaplan, Addison Wesley, (Indian Ed., from Narosa Publishing House, New Delhi), 2002.
5. Introduction to nuclear physics , S.B Patel
6. Concept of Nuclear Physics, B.L. Cohen, McGraw-Hill, 2003.
7. Nuclear & Particle Physics: An Introduction, B. Martin, Willey, 2006.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - III

RP: **M-PH635P**

Research Project /Dissertation (Core)**:**

END of SEM III

M.Sc. Sem- IV (Physics Major Subject)

Level 6.5

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				Theory	Tut	Prac					
				Th	Tu	P		Duration of Examination (Hrs)	End Semester Evaluation (ESE)	Continuous Internal Evaluation (CIE)	Minimum Passing Marks
1	DSC	Statistical Physics	M-PH641T	4	--	--	4	3	80	20	40
		Electrodynamics	M-PH642T	4	--	--	4	3	80	20	40
		DSC Lab	M-PH643P	--	--	8	4	4-6	80	20	50
2	DSE	3. Material Science 4. Nuclear Physics-II	M-PH644T	4	--	--	4	3	80	20	40
3	RP	Research Project /Dissertation (Core)	M-PH645P	--	--	12	6	--	75	75	75
				12	**--**	**20**	**22**		**395**	**155**	**-**

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

DSC: **M-PH641T**

Statistical Physics

PAPER- I

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

OBJECTIVES:

1. To disseminate the importance of statistical mechanics
2. To solve the problems in classical and quantum domains by using statistical mechanics
3. Provide opportunities for scientific study and creativity.

OUTCOMES:

1. Students should be able to apply statistical tools to solve the problems in Physics
2. Students should be able identify the connection between statistical mechanics and thermodynamics
3. Students should be able to compare and apply Classical and quantum distributions

Unit I **15 hrs.**

Scope and aim of statistical mechanics, mean values, standard deviation, variance, probability distribution, binomial, Poisson and Gaussian distributions, Maxwell velocity distribution, momentum, and energy distribution, Microstates and macrostates, phase space

Unit II **15 hrs**

Postulate of equal a priori probability, Ergodic hypothesis, Liouville's theorem, Statistical equilibrium, ensembles (micro-canonical, canonical, and grand-canonical), partition function, free energy and connection with thermodynamic quantities, barometric formula, ideal gas, Gibbs paradox, equipartition theorem.

Unit III **15 hrs**

Fundamentals of quantum statistical mechanics, Symmetry of wave functions, BE and FD Statistics, Boltzmann limit of Bosons and Fermions, Ideal Bose system: Bose-Einstein condensation, Bose temperature, specific heat from lattice vibration, Debye model

Unit IV **15 hrs.**

Ideal Fermi system: Fermi energy as a function of temperature, Fermi temperature, mean energy of fermions at absolute zero, atomic nucleus as an ideal fermion gas, Fermionic condensation, Fermi gas in metals, Electronic specific heat

Text and Reference Books:

1. Fundamentals of Statistical Physics: B. B. Laud
2. Statistical and Thermal Physics: F. Reif
3. Statistical Mechanics: Loknathan and Gambhir
4. Statistical Physics: Landau and Lifshitz

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

DSE: **M-PH642T**

Electrodynamics

PAPER- III

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

Course Objectives:

- To provide students with a solid understanding of the fundamental concepts and principles of electrostatics and magnetostatics.
- To introduce students to Maxwell's equations and their applications in time-varying fields.
- To develop students' ability to apply mathematical tools and techniques to solve problems in electrodynamics.
- To familiarize students with electromagnetic wave equations and the behavior of electromagnetic waves in different media.
- To explore the concepts of radiation emission and the interaction of electromagnetic fields with matter.
- To enable students to analyze and interpret electromagnetic phenomena and their practical applications in various fields.
- To cultivate critical thinking, problem-solving skills, and the ability to apply electrodynamics principles to real-world scenarios.

Program Outcomes:

By the end of the course, students should be able to:

- Understand and apply the principles of electrostatics and magnetostatics, including Gauss's law, Ampere's law, boundary conditions, and the Biot-Savart law.
- Solve boundary value problems and apply uniqueness theorems and the method of images in electrostatics and magnetostatics.
- Comprehend Maxwell's equations, including the differential form of Gauss's law and Ampere's law, and their applications in time-varying fields.
- Analyze and solve problems related to electromagnetic potentials, including scalar and vector potentials.
- Understand the energy, force, and momentum relations in electromagnetic systems and apply Poynting's theorem.
- Comprehend electromagnetic wave equations and analyze the behavior of electromagnetic waves in different media, including reflection, refraction, and the skin effect.
- Understand gauge transformations and apply them in different gauges.
- Analyze radiation emission phenomena, including the radiation of electric dipoles, magnetic dipoles, and moving charges.
- Apply electrodynamics principles to analyze the radiation and fields of oscillating sources and antennas.
- Interpret and evaluate electromagnetic phenomena and their practical applications in various fields, such as electrical engineering, telecommunications, and optics.
- The provided reference books offer additional resources and perspectives to further enhance students' understanding of electrodynamics, and they can be used as supplementary materials for the course.

Unit-I: Electrostatics and Magnetostatics: **15 hrs.**

Dirac delta function, Gauss's law and applications, Differential form of Gauss's law, Poisson and Laplace's equations, Electrostatic potential energy, Boundary conditions, Uniqueness theorems, Method of images, Multipole expansion.

Biot-Savart law, Ampere's law, Differential form of Ampere's law, Vector potential, Magnetic field of a localized current distribution, Boundary conditions.

Unit-II: Time varying fields and Energy, force, momentum relations: **15 hrs.**

Faraday's law, Maxwell's displacement current, Maxwell's equations, Maxwell's equations in matter, Scalar and vector potentials,

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.

Unit-III: Electromagnetic wave equations: **15 hrs.**

Electromagnetic wave equations, Electromagnetic plane waves in stationary medium, Reflection and refraction of electromagnetic waves at plane boundaries (Normal and Oblique incidence), Electromagnetic waves in conducting medium, Skin effect and skin depth.

Lorentz's and Coulomb's gauges, Gauge transformations, Wave equations in terms of electromagnetic potentials, D'Alembertian operator,

Unit IV: Radiation emission: **15 hrs.**

Electric dipole, electric quadrupole and magnetic dipole radiation, Radiation by a moving charge: Lienard-Wiechert potentials of a point charge, Larmor's formula, Angular distribution of radiation. Fields and radiation of a localized oscillating source, radiation from a half wave antenna, radiation damping.

Reference Books

1. Introduction to Electrodynamics: David Griffiths (PHI)
2. Electrodyanamics J. D. Jackson
3. Introduction to Electrodynamics, A. Z. Capri and P. V. Panat (Narosa)
4. Classical theory of fields, Landau &Lifshitz
5. Electrodynamics, W. Panofsky and M. Phillips
6. Electromagnetism and Classified Theory, A. D. Barut, Dover
7. Electromagnetic theory and Electrodynamics, by Satya Prakash, KedarNath and Co.Meerut.
8. Electromagnetics by B.B.Laud, Willey Eastern.
9. Electrodynamics by Kumar Gupta and Singh.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

DSC: **M-PH643P**

Practicals

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

1. Flashing & quenching in Neon Gas.
2. E/m of electron.
1. Determination of ionization potential of lithium
2. X-ray diffraction by TELEXOMETER.
3. Study of emission spectra of iron (Iron arc).
4. Determination of Dissociation Energy of Iodine Molecule by photography of the absorption band of Iodine in the visible region.
5. Study of Stark effect
6. Study of Molecular Spectra
7. Determination of Rydberg's constant
8. Determination of Plank's constant
9. To study polarization of light using Babinet compensator
10. . E.S.R. of DPPH.
11. To measure magnetic fields produced by a current carrying wire
12. To study and verify Faraday's Law of Electromagnetic Induction
13. To measure magnetic susceptibility using Quinke's method/Gouy's Method
14. To study Biot-Savart's law
15. To study Hall effect
16. Solar cell Characterization
17. B-H Curve/ Magnetic Hysteresis curve experiment
18. To study Electrical/Dielectric Breakdown of air
19. To investigate the resonance and frequency response characteristics of an RLC circuit and verify its compatibility.

Designing of innovative experiments by students based on the laws of electrodynamics

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

DSE: **M-PH644T**

Material Science

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

OBJECTIVES:

1. To disseminate the deep knowledge of phase diagram, phase transformation
2. To disseminate the fundamental knowledge of diffusion in solids, synthesis, processing of materials and structure determination
3. Provide opportunities for scientific study and creativity within a global context that will stimulate and challenge the students.

OUTCOMES:

1. Students understand the phase diagram, phase transformation
2. They understand the basics of diffusion in solids, processing of materials and structure determination.
3. Apply the knowledge to solve problems based on above properties to strengthen their basics

Unit-I **15 hrs.**

Equilibrium and kinetics: Stability and metastability, Basic thermodynamic functions, Statistical nature of entropy, Kinetics of thermally activated process.

Phase diagrams: The phase rule, free energy composition diagram, correlation between free energy and phase diagram, calculation of phase boundaries, thermodynamics of solutions, single component system (water), two component system containing two phases and three phases, Binary phase diagrams having intermediate phases, Binary phase diagrams with eutectic system. Lever principle, maximum, minimum, super lattice, miscibility gap, microstructure changes during cooling, application to zone refining.

Unit – II **15 hrs.**

Phase transformations: Time scale for phase changes, peritectic reaction, eutectoid and eutectic transformations, order disorder transformation, transformation diagrams, dendritic structure in alloys, transformation on heating and cooling, grain size effect on rate of transformation at constant temperature and on continuous cooling, grain size effect on rate of transformation, nucleation kinetics, growth kinetics, interface kinetics leading to the crystal growth.

Unit-III **15 hrs.**

Diffusion in solids: Fick's laws and their solutions, the Kirkendall effect, mechanism of diffusion, temperature dependence of diffusion co-efficient, self-diffusion, interstitial diffusion, the Snoek effect in diffusion, diffusion in ionic crystals, diffusion path other than the crystal lattice, thermal vibrations and activation energy, diffusion of carbon in iron.

Concept of Synthesis: Concept of equilibrium and nonequilibrium processing and their importance in materials science. Synthesis of materials: Physical method – Bottom up: cluster beam evaporation, Ion beam deposition, Gas evaporation, Chemical method – Hydrothermal, combustion, bath deposition with capping techniques and top down: Ball milling. Thermal decomposition – reduction methods.

UNIT-IV 15 hrs.

Processing of materials: Metallic, non-metallic and other materials. Only basic elements of powder technologies, compaction, sintering calcination, vitrification reactions, with different example, porosity. Quenching: concept, glass formation.

Diffraction techniques: Electron and neutron diffraction. Interpretation of x-ray powder diffraction patterns, Identification & quantitative estimation of unknown samples by X-ray powder diffraction technique.
Microscopic techniques: TEM, SEM & STEM, AFM and XPS.

References:

1. Vanvellak: Materials Science.
2. V. Raghvan: Materials Science.
3. D. Kingery: Introduction to ceramics.
4. R. E. Reedhil: Physical metallurgy.
5. Kittel: Solid state physics, Vth edition.
6. M. A. Azaroff: Elements of crystallography
7. Chemical approaches to the synthesis of inorganic materials, C. N. R. Rao Wiley Eastern Ltd.1994.
8. Materials Science and Engineering – An Introduction, W. D. Callister, Jr. John Wiley & Sons,1991.
9. Nanostructured Materials and Nanotechnology, Hari Singh Nalwa, Academic Press (1998).

Practicals:

1. Differential thermal analysis of BaTiO3-PbTiO3 solid solution.
2. To study electrochemical method of corrosion control.
3. Dielectric behaviour of LiNbO3 and BaTiO3 in crystals and ceramics.
4. Electrical conductivity of ionic solids.
5. To test hardness of a material by Brinell hardness tester.
6. Photo elasticity study.
7. Multiple beam interferromentric study of surfaces.
8. Thermal conductivity of bad conductor.
9. Thermal expansion coefficient of metals.
10. Study of transport property in solid electrolytes.
11. Verification Nernst law/Oxygen sensor.

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

DSE: **M-PH644T**

Nuclear Physics-II

Marks- 100 (Credit 4, 4h/week) **Time- 60 hours**

SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

NUCLEAR AND PARTICLE PHYSICS II

OBJECTIVES:

1. To disseminate the knowledge of nuclear reactions, decay processes, elementary particles

2. To disseminate the fundamental knowledge of particles counters

3. Provide opportunities for scientific study and creativity

OUTCOMES:

1. Students gain knowledge of nuclear properties, decay processes, elementary particles

2. They gain knowledge of particles counters

3. Apply the knowledge to solve problems based on above properties to strengthen their concepts

UNIT-I: Nuclear decay 7.5 **hrs**

Radioactive decay, Unit of Radioactivity, laws of successive transformation, dosemetry, Alpha Decay: Velocity of Alpha Particles, Disintegration Energy, Range-Energy Relationship, Geiger-Nuttal Law, Beta decay: three forms of β- decay, Angular momentum and parity, selection rules, allowed and forbidden transitions, non conservation of parity in β- decay, Origin of Beta Spectrum-Neutrino Hypothesis, γ – decay, absorption law of gamma rays, Nuclear isomerism, Coulomb excitation

UNIT II: Nuclear reactions **7.5 hrs**

Nuclear reactions: conservation laws, mechanism, Q- value equation, Reaction cross section, compound nucleus, direct reactions, partial wave analysis, Fission and Fusion Reactions, Nuclear fission, nuclear fusion, stellar energy, chain reaction and critical mass,

UNIT II: Nuclear Reactors 7.5 Hrs

Reactors: Fission Chain Reaction, Four Factor Formula, Multiplication Factor, General Properties and Concepts of Nuclear Reactors, Reactor Materials, Types of Reactors, Reactors Developed in India

UNIT IV: Elementary Particles **7.5 Hrs**

Elementary particles: classification, their interaction, types: weak, strong and electromagnetic, gravitational interactions, their quantum numbers (charge, lepton number, baryon number, iso-spin, strangeness etc), Gell – Mann - Nishijima formula, conservation laws, CPT theorem, Quark theory: assumptions, properties, classification, colour of quark & its importance

Reference Books:

1. Nuclear Physics, D.C.Tayal,(Himalaya Publishing House, Mumbai)
2. Introduction to Elementary Particles, D. Griffiths, 2nd Ed., Academic Press, 2008.
3. Introductory Nuclear Physics, S.S.M. Wong, 2nd Ed., Wiley VCH, 2004
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SUBJECT: PHYSICS

M.SC. –II SEMESTER - IV

RP **M-PH645P**

Research Project /Dissertation (Core)

END of SEM IV