"Dissemination of Education for Knowledge, Science and Culture"
-Shikshanmaharshi Dr. Bapuji Salunkhe

Shri Swami Vivekanand Shikshan Sanstha's

Vivekanand College, Kolhapur (Empowered Autonomous).

DEPARTMENT OF PHYSICS
Two - Years PG Programme
Department/Subject Specific Core or Major (DSC)

Curriculum, Teaching and Evaluation Structure

for

M.Sc. II - Physics

Semester – III & IV

(Implemented from academic year 2024-25 onwards)

VIVEKANAND COLLEGE, KOLHAPUR (AUTONOMOUS)

Program Outcomes (POs):

PO1	The student will acquire a job efficiently in diverse fields such as Science and Engineering, Industry, Education, Banking, Public Services, Business.
PO2	The student will effectively communicate their knowledge of physics through a variety of oral, Written and computational modalities.
PO3	The student will be able demonstrate a purposeful knowledge of scientific literature and ethical issues related to physics.
PO4	Assess the errors involved in an experimental work and make recommendations based on the results in an effective manner also gain the knowledge of Physics through theory, Practical's and research project.

Program Specific Outcomes (PSOs):

PSO1	The student will acquire a comprehensive knowledge and sound understanding of fundamentals of Physics and will be able to apply a scientific knowledge gained through coreand specialized physics papers
PSO2	The student will be able to develop practical, analytical and mathematical skills in Physics and determine the appropriate level of technology in practice • Experimental design and implementation. • Analysis of experimental data and awareness of handle the sophisticated instruments/equipments. • Numerical and mathematical methods in problem solving. • Acquire a range of general skills. • To evaluate information. • To use computers productively. • To communicate with society effectively and learn independently. • To develop the skill to plan, Execute and report the results of an extended experimental or theoretical Physics based on project in Masters Programme. • Demonstrate, Solve and an understanding of major concepts in all disciplines of Physics
PSO3	Understand and apply principles of physics for understanding the scientific phenomenon in classical and quantum physics.
PSO4	The student will become effective researcher who will be able to publish scientific papers, Articles on a given topic of study and gain knowledge to continue research at the higher degree (PhD) level.

VIVEKANAND COLLEGE, KOLHAPUR (EMPOWERED AUTONOMOUS)

Department of Physics

Departmental Teaching and Evaluation scheme

Three/Four- Years PG Programme

Department/Subject Specific Core or Major (DSC)

(as per NEP-2020 Guidelines)

M.Sc. II, Semester-III & IV

Sr. No.	Course Abbr.	Course code	Course Name	Teaching Scheme Hours/week		Examination Scheme and Marks				Course Credits
				TH	PR	ESE	CIE	PR	Marks	
Semester-III										
1	DSC-V	DSC12PHY31	Statistical Mechanics	4	-	80	20	-	100	4
2	DSC-VI	DSC12PHY32	Atomic and Molecule Physics	4	-	80	20	-	100	4
4	DSE	DSE12PHY31	Thin solid films: Deposition and Properties	4	-	80	20	-	100	4
5		DSE12PHY32	Special Materials	4	-	80	20	-	100	4
6	DSC-PR-III	DSC12PHY39	DSC-Physics Lab-III	-	6	-	-	150	150	6
7	RPR-I	RPR12PHY31	Research Project- I							
Semester –III			**Total**	**12**	**6**	**320**	**80**	**100**	**550**	**22**
Semester- IV										
1	DSC-VII	DSC12PHY41	Electrodynamics	4	-	80	20	-	100	4
2	DSC-VIII	DSC12PHY42	Nuclear and Particle Physics	4	-	80	20	-	100	4
3	DSE	DSE12PHY41	Physical Properties of Solids	4	-	80	20	-	100	4
4		DSE12PHY42	Nanostructured Materials	4	-	80	20	-	100	4
5	DSC-PR-IV	DSC12PHY49	DSC-Physics Lab-IV	-	6	-	-	100	100	4
6	RPR-I	RPR12PHY41	Research Project- II		6	-	-	150	150	6
Semester –IV			**Total**	**12**	**10**	**240**	**60**	**250**	**550**	**22**

M.Sc. II, Semester-III (DSC-V)
Statistical Mechanics
DSC12 PHY31
Theory: 60hrs
Marks-80 (Credits: 04)

Course outcomes: Statistical Mechanics

CO1	Students learn the classical statistical tools as required for analyzing research data.
CO2	Students gained an understanding about classical statistics.
CO3	Students gained an understanding about Quantum statistics.
CO4	Students gained an understanding about problem solutions regarding classical Quantum statistics.

Statistical Mechanics

Unit	Syllabus	Hours
Unit 1	**Contact between Statistics and Thermodynamics:** Fundamental postulate of equilibrium statistical mechanics, Basic concepts – Phase space, ensemble, a priori probability, Liouville's theorem (Revision). Fluctuations of physical quantities, Statistical Equilibrium, Thermodynamic Laws and their consequences (in brief), Thermodynamic Functions – Entropy, Free energy, Internal Energy, Enthalpy (definitions), Maxwell's Equations (only equations), Contact between statistics and thermodynamics – Entropy in terms of microstates, Gibb's paradox, Sackur–Tetrode equation.	15
Unit 2	**Classical Statistical Mechanics:** Micro canonical Ensemble– Micro canonical distribution, Entropy and specific heat of a perfect gas, Entropy and probability distribution, Canonical Ensemble– Canonical Distribution, Partition function, Calculation of free energy of an ideal gas, Thermodynamic Functions, Energy fluctuations, Grand Canonical Ensemble– Grand Canonical distribution, Thermodynamic Functions, Number and Energy fluctuations.	15
Unit 3	**Quantum Statistical Mechanics:** Quantum Statistics: Distinction between MB, BE and FD distributions, Quantum distribution functions – Bosons and Fermions and their distribution functions, Boltzmann limit of quantum gases, Partition function, Ideal Bose gas, Bose -Einstein Condensation, Specific heat of solids (Einstein and Debye models), Phonon gas, Liquid He^4: Second Sound, Ideal Fermi gas: Weakly and strongly degenerate, Fermi temperature, Fermi velocity of a particle of a degenerate gas , Electron gas: Free electron theory of metals, Pauli paramagnetism, white dwarfs, Brownian motion: Einstein Smoluchowski theory, Langevin theory, Approach to equilibrium: Fokker-Planck equation, the fluctuation-dissipation theorem.	15
Unit 4	**Phase Transitions and Critical Phenomenon:** Phase Transitions, Conditions for phase equilibrium, First order Phase	15

	Transition: Clausius - Clayperon equation, Second order phase transition, The critical indices, Weakly Interacting Gases, Weiss Molecular theory of paramagnetism, The Ising Model of a Ferromagnetism.	

Reference books:

1) Statistical Mechanics Theory and Applications- S K Sinha, Tata McGraw-Hill, 1990.
2) Introduction to Statistical mechanics- B B Laud, Macmillan, N Delhi, 1981.
3) Statistical Mechanics- R K Pathria, Pergamon press, 1972.
4) Statistical and thermal Physics- F. Reif, McGraw-Hill, 1965.
5) Statistical Physics- L. D. Landau, E. M. Lifshitz, Pergamon press, 1958.

M.Sc. II, Semester-III (DSC-V)
Atomic and Molecular Physics
DSC12PHY32
Theory: 60hrs
Marks-80 (Credits: 04)

Course outcomes: Atomic and Molecular Physics

CO1	The fundamental understanding of the atom Model for two valance electron.
CO2	Better understanding of the Zeeman and Paschen-Back Effect
CO3	The student shall gain a sound understanding of the basics of Microwave
CO4	The student shall gain a sound understanding of the basics Infra-Red Spectroscopy

Atomic and Molecular Physics

Unit	Syllabus	Hours
Unit 1	**Atomic Spectra:** Quantum states of an electron in an atom, electron spin, spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, ll-coupling, ss-coupling, LS or Russell - Saunder's coupling; the Pauli exclusion principle, Coupling schemes for two electrons, Γ- factors for LS coupling, Lande interval rule, jj coupling, branching rules, selection rules, Intensity relations.	15
Unit 2	**Effect of magnetic and electric field on atomic spectra:** The magnetic moment of the atom, Zeeman effect for two-electrons, Intensity rules for Zeeman effect, Paschen-Back effect for two electrons, Stark effect of hydrogen, weak field Stark effect in hydrogen, strong field Stark effect in hydrogen, origin of hyperfine structure, Inner shell vacancy, X- ray and Auger transitions, Compton effect.	15
Unit 3	**Molecular spectra:** Molecular physics – covalent, ionic and Vander Waal's interaction, Classification of molecules: linear, symmetric tops, spherical tops, asymmetric tops; rotational spectra: the rigid diatomic molecule, the non- rigid rotator, spectrum of a non-rigid rotator, techniques and instrumentation of microwave spectroscopy, chemical analysis by microwave spectroscopy, the vibrating diatomic molecule: the energy of a diatomic molecule, the simple harmonic oscillator, the anharmonic oscillator, the diatomic vibrating-rotator, vibrational rotational spectra, techniques and instrumentation of infra-red spectroscopy, chemical analysis by infra-red spectroscopy.	15
Unit 4	**Electronic, Nuclear and Raman spectra:** Revision on electronic spectra of diatomic molecules, electron spins resonance, nuclear magnetic resonance, chemical shift, Frank-Condon principle, dissociation energy and dissociation products, rotational fine structure of electronic-vibration, transitions, Born-Oppenheimer approximation, separation of electronic and nuclear motions in molecules, band structures of molecular	15

	spectra, Raman spectra: Pure rotational Raman spectra, vibrational Raman spectra, polarization of light and Raman effect, techniques and instrumentation of Raman spectroscopy.	

Reference books:

1) Introduction to Atomic Spectra – H.E. White, Mac-Graw Hill,1934.
2) Fundamentals of Molecular Spectroscopy 4th Edition. – C.N. Banwell, Tata MacGraw Hill,2008.
3) Molecular Structure and Spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd. Spectra of diatomic Molecules, Vol. I – G. Herzberg, N.J.D. van Nostrand, 1950.
4) Spectroscopy, Vol. I, II and III – B.P. Straughan and S. Walker, Chapman, and Hall,1976.
5) Introduction to Molecular Spectroscopy – G.M. Barrow, McGraw Hill,1962.
6) Molecular Spectroscopy – J.M. Brown, Oxford University Press,1998.

Elective Paper

M.Sc. II, Semester-III

Thin solid films: Deposition and properties

DSE12PHY31

Theory: 60hrs

Marks-80 (Credits: 04)

Course Outcomes: Thin solid films: Deposition and properties

CO1	Provide a critical and systematic understanding on advanced Physical methods of thin film deposition like vacuum, evaporation, Chemical vapor deposition, sputtering, etc
CO2	Provide a critical and systematic understanding on advanced chemical methods of thin film deposition like Chemical bath deposition, electro deposition, Spray pyrolysis , (SILAR), Sol-gel, hydrothermal deposition techniques etc.
CO3	Learn the basics of the Nucleation growth processes and thickness measurement
CO4	Understanding of electrical and magnetic properties in solids, X-ray diffraction, SEM, TEM, X-ray Energy Dispersive Analysis (EDX), X-ray photoelectron spectroscopy (XPS).

Thin solid films: Deposition and properties

Unit	Syllabus	Hours
Unit 1	**Physical methods of thin film deposition:** Vacuum deposition apparatus: Vacuum systems, substrate deposition technology, substrate materials, Thermal Evaporation methods: Resistive heating, Flash evaporation, Arc evaporation, laser evaporation, electron bombardment heating, Sputtering: sputtering variants, glow discharge sputtering, Magnetic field assisted (Triode) sputtering, RF Sputtering, Ion beam sputtering, sputtering of multi- component materials.	15
Unit 2	**Chemical methods:** Chemical vapor deposition: Common CVD reactions, Methods of film preparation, laser CVD, Photochemical CVD, Plasma enhanced CVD, Chemical bath deposition, Electro deposition, Spray pyrolysis, successive ionic layer adsorption reaction method (SILAR) method, Sol-gel method, Hydrothermal method.	15
Unit 3	**Nucleation growth processes and thickness measurement:** Condensation process, Langmuir-Frenkel theory of condensation, Theory of nucleation and growth process, Thickness measurements: Electrical methods, Microbalance monitors, mechanical method, radiation absorption and radiation emission methods, optical interference methods: photometric method, spectrometric method, interference fringes, X-ray interference fringes.	15
Unit 4	**Properties and characterization of thin films:** Mechanical properties of thin films: Introduction to elasticity, plasticity, and mechanical behavior, Electrical and magnetic properties of thin films, Optical	15

	properties of thin films, Structural characterization: X-ray diffraction, Scanning electron microscopy, Transmission electron spectroscopy, chemical characterization: X-ray Energy Dispersive Analysis (EDX), X-ray photoelectron spectroscopy (XPS).	

Reference Books:

1) Thin Film Phenomena- K. L. Chopra McGraw -Hill Book Company, N, 1969.
2) The Materials Science of Thin Films- Milton Ohring, Academic Press,1992.
3) Properties of Thin Films- Joy George, Marcel, and Decker,1992.
4) Physics of Thin Films- Ludmila Eckertová, Springer, 1986.
5) Thin Film Technology- O. S. Heavens, Methuen young books, 1970.
6) Solid State Physics- N.W. Ashcroft, N. D. Mermin, Harcourt College Publishers, 1976.
7) Chemical Solution Deposition of Semiconductor Films- G. Hodes, Marcel Dekker Inc.,2002.

OR

Elective Paper

M.Sc. II, Semester-III

Special Materials

DSE12PHY32

Theory: 60hrs

Marks-80 (Credits: 04)

Course Outcomes: Thin solid films: Deposition and properties

CO1	Understanding the components, types, properties, and applications of composites is crucial for fiber composite
CO2	Understanding the types and properties of glasses allows for their effective use in various industries, from construction goods to high-tech applications in electronics and optics.
CO3	Understanding and harnessing these properties, engineers and scientists can design and develop materials
CO4	Understanding these properties allows for the development and optimization of advanced devices across multiple industries.

Special Materials

Unit	Syllabus	Hours
Unit 1	**Composite materials:** Introduction, Reinforcing materials for fibrous composites, Manufacture of fiber composites, Elastic properties of a composite, Strength of a fiber composite, Specific stiffness and specific strength, Toughness of fibre composites, Fracture toughness of polyblends.	15
Unit 2	**Glasses:** Glasses: Types of glasses, role of oxides in glasses, glass transition temperature, optical properties of glasses, electrical properties of glasses, electronically conducting glasses, special glasses, metallic glasses.	15
Unit 3	**Functional Materials** **Nanophase materials:** Introduction, synthesis and techniques, Nucleation and growth mechanism, properties of Nanophase Materials, Applications. **Advanced Ceramics**: Introduction, Classification of Ceramics, Structure of the Ceramics, Ceramic Processing, Properties of Ceramics, Applications. **Polymer Materials:** Introduction, Polymerization Mechanism, Degree of Polymerization, Classification of Polymers, Structures of polymer and preparation methods, important properties and applications of polymers. (Nylon, Polyesters, Silicones, Composites, Composite material including nanomaterial)	15
Unit 4	**Ferroelectrics, Piezoelectrics and Pyroelectrics:**	15

	Ferroelectrics: Ferroelectric phenomena, Types of ferroelectrics, Theory of ferroelectric displacive transitions, Ferroelectric and antiferroelectric transition, Formation and dynamics of ferroelectric domains, Experimental evidence of domain structure, ferroelectric materials, and their applications. **Piezoelectric:** Piezoelectric phenomena, Phenomenological approach to piezoelectric effects, Piezoelectric parameters and their measurements, Piezoelectric materials, and their applications. **Pyroelectrics:** Pyroelectric phenomena, Phenomenological approach to pyroelectric effects, Pyroelectric parameters and their measurements, pyroelectric materials, and their applications.	

Reference Books:

1) Modern composite materials - L. J. Broutman and R H Krock Addition-Wesley Pub. Co., Massachusetts, 1967.
2) Glass science - R H Doremus, John Wiley and sons, N. Y.,1973.
3) Physical properties of glass - D. G. Holloway Wykeham publications, London, 1973.
4) Introduction to ceramics - W. D. Kingery, John Wiley and sons, N. Y., 1960.
5) Solid State Physics- M.A.Wahab; Structure and Properties of Materials, Alpha Science International,2005.

M.Sc. II, Semester-III
Physics Lab-III (DSE-PR III)
DSC12PHY39
Mark: 150 (Credits 06)

List of Experiments

Group I:

1) Thin film deposition by SILAR method.
2) Thin film deposition by electro-deposition method.
3) Thin film deposition by hydrothermal method.
4) Thin film deposition by reflux method.
5) Thin film deposition by dip-coating method.
6) Thin film deposition by CBD method.
7) Microwave assisted synthesis of thin film.
8) Thin film deposition by spray pyrolysis method.

Group II:

1) Rietveld method of structure refinement.
2) Calculation of XRD peak positions and intensities.
3) Thickness measurement of thin film by Gravimetric Method.
4) Electrical resistivity of thin film by 2 probe method.
5) Thermoelectric power of thin film.
6) Contact angle measurement of thin film.
7) Determination of band gap energy of thin film.
8) Measurement of dielectric constant.

Research Project - I (4 credits)

M.Sc. II, Semester-IV (DSC-VIII)
Electrodynamics
DSC12PHY41
Theory: 60hrs
Marks-80 (Credits: 04)

Course outcomes: Electrodynamics

CO1	The fundamental understanding of the Maxwell's equations and propagation of plane electromagnetic wave
CO2	Better understanding of the Time dependent potentials and fields
CO3	The student shall gain a sound understanding of Electromagnetic fields and Radiations
CO4	The student shall gain a sound understanding of the Relativistic mechanics and covariance

Electrodynamics

Unit	Syllabus	Hours
Unit 1	**Maxwell's Equations and E.M. Waves:** Maxwell's Equations: microscopic and macroscopic forms (revision), Maxwell's equations in free space, dielectrics and conductors, conservation of the bound charge and current densities (Equation of Continuity and Displacement Current), E.M. wave equations in waveguide of the arbitrary cross section: TE and TM modes; Transmission lines and wave guides, rectangular and circular waveguides , dielectric waveguide, resonant cavity. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction.	15
Unit 2	**Time –Dependent Potentials and Fields:** Scalar and vector potentials: coupled differential equations, Gauge transformations: Lorentz and Coulomb Gauges, Retarded Potentials, Lienard – Wiechert Potentials, Fields due to a charge in the arbitrary motion.	15
Unit 3	**Radiation from Accelerated Charges and Radiation Reaction:** Fields of charge in uniform motion, applications to linear and circular motions: cyclotron and Synchrotron radiations, Power radiated by point charge – Larmor's formula, Angular distribution of radiated power, Cerenkov radiation and Bremsstrahlung (qualitative treatments). Radiation Reaction: criteria for validity, Abraham –Lorentz formula, Physical basis of radiation reaction –self force.	15
Unit 4	**Electrodynamics and Relativity:** Geometry of Relativity, the Lorentz Transformations, The Structure of Space time, Relativistic Mechanics, Proper Time and Proper Velocity, Relativistic Energy and Momentum, Relativistic Kinematics, Relativistic Dynamics, Relativistic Electrodynamics Field Tensor, Relativistic Potential. Four vectors and Tensors: covariance of the equation of Physics, Transformation of	15

	Electric field, Lorentz transformation as orthogonal Transformation in Fourier dimensions, Proper time and light cone, Relativistic Particle- Kinematics and dynamics, Covariant Lorentz force.	

Reference books:

1) Introduction to Electrodynamics – D. J. Griffiths (Prentices- Hall (3rd Edn), 2002.
2) Foundation of E.M. Theory- J. R. Reitz, F.J. Milford & R.W. Christy, Narosa Publication House 3rd edition 1993.
3) Classical Electrodynamics – J. D. Jackson, Wiley Eastern 2nd edition, 1975.
4) Classical Electrodynamics –S. P. Puri, Tata McGraw Hill, 1990.
5) Electromagnetics - Laud B. B. - New Age International Private Limited; 3rd edition, 2011.

M.Sc. II, Semester-IV (DSC-VIII)
Nuclear and Particle Physics
DSC12PHY41
Theory: 60hrs
Marks-80 (Credits: 04)

Course Outcomes: Nuclear and Particle Physics

CO1	Acquire basic knowledge about Nucleon-Nucleon interaction, deuteron problem, n-p ,p-p and N-N scattering , nuclear forces etc.
CO2	Understand the Elementary ideas of alpha, beta and gamma decays, nuclear fission and fusion reactions mechanism.
CO3	Develop the understanding of cosmic rays and elementary particles and their properties.
CO4	Learn about the concept of particle physics classification like charge, spin, parity, isospin, strangeness etc

Nuclear and Particle Physics

Unit	Syllabus	Hours
Unit 1	**Nucleon-Nucleon Interaction:** Nature of the nuclear forces, form of nucleon-nucleon potential, Deuteron problem: The theory of ground state of deuteron, excited states of deuteron, n-p scattering at low energies (cross-section, phase shift analysis, scattering length, n-p scattering for square well potential, effective range theory); p-p scattering at low energies (cross-section, experiment and results) ; exchange forces, tensor forces; high energy N-N scattering (qualitative discussion only of n-p and p-p scatterings), charge-independence and charge symmetry of nuclear forces.	15
Unit 2	**Nuclear Models:** Evidences for shell structure, single-particle shell model, its validity and limitations, collective model: collective vibration and collective rotation, single particle motion in a deformed potential.	15
Unit 3	**Nuclear Reactions:** Elementary ideas of alpha, beta and gamma decays and their classifications, characteristics, selection rules and basic theoretical understanding. Nuclear reactions, reaction mechanism, Compound nucleus reaction (origin of the compound nucleus hypothesis, discrete resonances, continuum states), optical model of particle-induced nuclear reaction and direct reactions (experimental characteristics, direct inelastic scattering, and transfer reactions). Fission and fusion, Fission, and heavy ion reactions.	15
Unit 4	**Particle Physics:** Classification of fundamental forces. Classification of Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellman-Nishijima formula. Quark model, CPT invariance. Application of symmetry arguments to particle reactions,	15

	Parity non-conservation in weak interaction, Relativistic kinematics.	

Reference Books:

1) Nuclear and Particle Physics- W.E. Burcham and M.Jobes, Addison Wesley, Longman, England, 1995.
2) Introduction to Particle Physics- M.P. Khanna (Prentice Hall, India, 1999.
3) Concept of Nuclear Physics- B.L. Cohen,Tata McGraw-Hill, 2005.
4) Nuclear Physics Principles and Applications- John Lilley, (John Wiley and Sons Asia), 2001.
5) Nuclear physics- D. C. Tayal. Himalaya Publishing House,1997.
6) Nuclear Physics- Iriving Kaplan Narosa, Madras, 1989.
7) Introduction to High Energy Physics- Donald H.Perkins,Addison Wesley, Massachusetts, 1982.

Elective Paper

M.Sc. II, Semester-IV

Physical properties of Solids

DSE12PHY41
Theory: 60hrs
Marks-80 (Credits: 04)

Course Outcomes: Physical properties of Solids

CO1	Understand the matter interaction Electronic Structure of Crystals
CO2	Identify the problems and applications of Transport Properties of Metals.
CO3	Acquire basic knowledge about Phonons, Plasmons, Polaritons, and Polarons
CO4	Impart the knowledge about the Defects in crystals

Physical properties of Solids

Unit	Syllabus	Hours
Unit 1	**Electronic Structure of Crystals:** Basic assumptions of Model, Collision or relaxation times, DC electrical conductivity, Failures of the free electron model, The tight-binding method, Linear combinations of atomic orbitals, Application to bands from s-Levels, General features of Tight-binding levels, Wannier functions, Other methods for calculating band structure, Independent electron approximation, general features of valence band wave functions, Cellular method, Muffin Tin potentials, Augmented plane wave (APW) method, Green's function (KKR) method, Orthogonalized Plane Wave (OPW) method Pseudo potentials.	15
Unit 2	**Transport Properties of Metals :** Drift velocity and relaxation time, The Boltzmann transport relation, The Sommerfeld theory of metals of electrical conductivity, The mean free path in metals, Thermal scattering, The electrical conductivity at low temperature, The thermal conductivity of metals, Dielectric Properties of insulators, Macroscopic electrostatic Maxwell equations, Theory of Local Field, Theory of polarizability, Clausius- Mossotti relation, Long- wavelength optical modes in Ionic crystals.	15
Unit 3	**Phonons, Plasmons, Polaritons, and Polarons:** Vibrations of monatomic lattices: first Brillion zone, group velocity, Long wavelength limit, Lattice with two atoms per primitive cell. Quantization of lattice vibrations, Phonon momentum Dielectric function of the electron gas, Plasma optics, Dispersion relation for Electromagnetic waves, Transverse optical modes in a plasma, Longitudinal Plasma oscillations, Plasmons, Polaritons, LST relations, Electron- electron interaction, Electron phonon interaction: Polarons.	15

Unit 4	**Defects in crystals:** Thermodynamics of point defects, Schottky and Frenkel defects, annealing, electrical conductivity of ionic crystals, color centers, Polarons and exciton, dislocations, strength of crystals, crystal growth, stacking faults and grain boundaries.	15

Reference Books:

1) Solid State Physics- N W Ashcroft and N D Mermin, HRW, International editions, 1996.
2) Introduction to Solid State Physics- C Kittle (4th edition) John Willey Publication, 1979.
3) Solid State Physics- A J Dekker, Macmillan India Ltd,1986.

OR

Elective Paper

M.Sc. II, Semester-IV

Nanostructured Materials

DSE12PHY42

Theory: 60hrs

Marks-80 (Credits: 04)

Course Outcomes: Nanostructured Materials

CO1	Understand materials at the nanoscale. These methods enable the development of innovative materials with unique properties that are revolutionizing various industries.
CO2	Understand techniques and characterization methods continue to drive innovation, enabling the development of new materials
CO3	Able to learn materials combine the unique properties of nanotechnology with the functional requirements of biomaterials
CO4	Student is learning Nano-materials science brings numerous benefits

Nanostructured Materials

Unit	**Syllabus**	**Hours**
Unit 1	**Nano-Material Synthesis and Characterization:** Material Synthesis: Physical Methods: Introduction, methods based on evaporation, sputter deposition, chemical vapour deposition, electro deposition, ion beam technique, Chemical Methods: Introduction, colloids and colloidal solutions, growth of nanoparticles, sol-gel method.	15
Unit 2	**Characterizations and Applications of Nanostructured Materials:** Material Characterization: Analysis by XRD, XPS, SEM/FESEM, FT-IR, UV-Vis, Raman Spectroscopy, AFM, TEM, TG-DTA, Wettability and contact angle measurement. Electronics, energy, automobiles, sports and toys, textile, cosmetic, domestic appliances, space, and defense, medical, nanotechnology and environment.	15
Unit 3	**Nano-Biomaterials:** Biomaterial requirements, Dental materials, bore materials, Reconstructive surgery materials, Drug delivery system, Carbon Nanomaterials as Nanocarriers for Drug Delivery: Concepts and Challenges, Delivery of Anticancer Drugs.	15
Unit 4	**Environmental and Social issues of Nano-Materials Science:** Recycling issue of materials science, World banned materials, Salty of hazards materials, Nanomaterials and health, Nanomaterials and the environment, Sustainable nonmanufacturing and green nanotechnology, Societal and ethical considerations.	15

Reference Books:

1) Physical metallurgy principles - R. E. Reed-Hill, 2nd Edition, Van Nostrand, 1973.
2) Structure and principle of engineering materials - R. M. Brick, A. W. Pense and R. B. Gordon, McGraw-Hill Kogakusha, Ltd., 1977.
3) Elements of materials science - L. H., Van Vlack, Addison-Wesley, 1989.
4) Introduction to ceramics - W. D. Kingery, John Wiley and sons,1960.
5) Carbon Nanomaterials for Biomedical Applications - Mei Zhang, Rajesh R. Naik, Liming Dai. Springer, 2016

M.Sc. II, Semester-IV
Physics Lab-IV (DSE-PR IV)
DSC12PHY49
Mark: 100 (Credits 04)

List of Experiments:

Group I:

[1] Particle size analysis by dynamic light scattering
[2] Photo electrochemical Solar Cell
[3] Characteristics of phototransistor and LDR
[4] Spectral response of solar cell
[5] Gas sensing properties of thin film
[6] I-V characteristics of solar panel
[7] Analysis of EIS spectrum
[8] I-V characteristics and solar cell parameters

Group II:

[9] Analysis of FT-IR and FT-IR spectra
[10] Cyclic Voltammetry and electro-chromism
[11] Super capacitive behaviour of MnO_2 sample
[12] Specific area by BET method
[13] Analysis of PL spectrum and calculation of life time of defects
[14] Analysis of TG-DTA pattern
[15] Analysis of XAFs pattern

Research Project Work - II (6 credits)

Vivekanand College, Kolhapur (Empowered Autonomous)

Nature of Question Paper

Theory: Time -3 hours, Marks-
80 Instructions: All questions are
compulsory.

Q.1 Select Correct Alternative **(8)**

1. …………………………………
   A) B) C) D)
2. …………………………………
   B) B) C) D)
3. …………………………………
   A) B) C) D)
4. …………………………………
   A) B) C) D)
5. …………………………………
   A) B) C) D)
6. …………………………………
   A) B) C) D)
7. …………………………………
   A) B) C) D)
8. …………………………………
   A) B) C) D)

Q.2 Attempt any four **(48)**

1……………………………………..
2………………………………………..
3……………………………………
4……………………………………..
5………………………………………..
6……………………………………

Q. 3 Attempt any four **(24)**

1……………………………………..
2………………………………………..
3……………………………………
4……………………………………..
5………………………………………..