



SWAMI VIVEKANAND  
**SUBHARTI**  
UNIVERSITY  
UGC Approved Meerut



AN ISO 21001: 2018 ORGANIZATION

OFFICE OF THE REGISTRAR  
Gp Capt M Yakoob  
M-in-D (Retd.), M.Tech.  
REGISTRAR  
registrar@subharti.org

Ref.No.U-508(i)/SVSU/2025/1626

Date:27.01.2025

**NOTIFICATION**

It is hereby notified for information of all the concerned that the Academic Council in its 34<sup>th</sup> meeting held on 25-07-2024 vide resolution No.34(9) has approved the revised syllabus (as per NEP-2020) of the following ordinance:

**Ordinance No.V-135(B14), relating to B.Sc.-Nanotechnology**

The copy of above is enclosed and shall be applicable from Academic Session 2022-23 onwards.

This issues with the approval of the Hon'ble Vice Chancellor.

*27.01.2025*  
*M. Yakoob*  
Registrar

Ref.No.U-508(i)/SVSU/2025/1626

Date: 27.01.2025

Copy forwarded to information of:

1. Hon'ble Vice-Chancellor
2. Controller of Examination
3. Dean-Academics
4. Director-IQAC
5. Dean-Faculty of Science (for compliance please)
6. CTO (with a request to upload the ordinance on University website)
7. Additional Registrar-Academics
8. Guard File

*27.01.2025*  
*M. Yakoob*  
Registrar



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Subhartipuram, NH-58, Delhi-Haridwar Bypass Road, Meerut-250005 (U.P.) INDIA

KERAL VERMA SUBHARTI COLLEGE OF SCIENCE  
SWAMI VIVEKANAND SUBHARTI UNIVERSITY

MEERUT



SYLLABUS

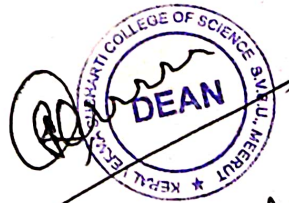
FOR

B.Sc. NANOTECHNOLOGY

UNDER

NEW EDUCATION POLICY

EFFECTIVE FROM 2022 – 2023



27/12/24


Dr. Nirdesh Kumar Singh  
HOD of Physics  
Keral Verma Subharti College of Science  
Swami Vivekanand Subharti University  
Meerut

Dr. Isray

Dr. Ekta

Dr. (Mr. Anant)

- References: 1. The Chemistry of Nanomaterials: Synthesis, Properties and Applications. C.N.R. Rao ,A. Muller, A.K.Cheetam (Eds.),(2004) WILEY-VCH Verlag GmbH&Co.,Weinheim
2. "Nanomaterials" B. Vishwanathan, 2010, Narosa Publishers
3. Nanofabrication towards biomedical applications, C.S.S.R.Kumar , J.Harmones .C.Leusenner (Eds), (2005) WILEY-VCH Verlag GmbH&Co., Weinheim
4. Synthesis, Properties, and Applications of Oxide Nanomaterials José A. Rodríguez, Marcos Fernández-García, Copyright © 2007 John Wiley & Sons, Inc.
5. Advanced Magnetic Structures, David Sellmyer and Ralph Skomski, Springer

  
Dr. Niraj Kumar Singh  
HOD of Physics  
Keral Verma Subharti College of Science  
Swami Vivekanand Subharti University  
Meerut

  
  
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ing geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.

1. Time line of major geological and biological events.
2. Origin of life on Earth.
3. Role of the biosphere in shaping the environment.
4. Future of evolution of the Earth and solar system: Death of the Earth.

#### **Disturbing the Earth – Contemporary dilemmas**

- (a) Human population growth.
- (b) Atmosphere: Green house gas emissions, climate change, air pollution.
- (c) Hydrosphere: Fresh water depletion.
- (d) Geosphere: Chemical effluents, nuclear waste.
- (e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

**Course Learning Outcomes:** This course will enable the students to:

#### **Reference Books:**

Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.  
Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books  
Holme's Principles of Physical Geology. 1992. Chapman & Hall.  
Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

### AREA ELECTIVE IV

#### Unit I

**Electronic Applications: Applications of nano in IC chips, STM based lithography-Molecular electronics- LEDs-Memories – CNT and Graphene based Electronic devices - transistor based sensors and its general applications- Applications of Nanomaterials in Space**

**Unit II Applications of Nanomagnetic materials: Nano magnetism- Bionanomagnetism- type of magnet materials –tag and drug delivery – hyperthermia- hypothermia-MRI**

**Unit III Application of Nanomaterials in storage devices. Types of storage devices- solid state memory- types of memory devices- role of nanoelectronics for memory devices –GMR-AMR effect- ultra –small head design- Longitudinal recording media- Superparamagnetic limit and its applications. Phase Change Memory Devices, FeRAM, MRAM, RRAM and Probe storage, molecular memory and atomic memory**

**Unit IV Environmental Applications- Bioremediation- removal of bacteria and microbes- sensors for DNA- Proteins, and Biological applications – self-assembly systems- tissue culture nano pharma.**

### AREA ELECTIVE III

Course Name: Physics of Earth	Course Code: BSC-H-PHY-604 C
Credits=L+T+P(6+0+0)	Hours=90
Objectives: To acquire basic knowledge about General characteristics and origin of the Universe; Structure, Dynamical Processes and Evolution of earth.	

#### Unit I: The Earth and the Universe:

- Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.
- General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.
- Energy and particle fluxes incident on the Earth.
- The Cosmic Microwave Background.

#### Unit II: Structure:

- The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
- The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.
- The Atmosphere: variation of temperature, density and composition with altitude, clouds.
- The Cryosphere: Polar caps and ice sheets. Mountain glaciers.
- The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.

#### Unit III: Dynamical Processes:

- The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and riftvalleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.
- The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, wind – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.
- The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones.  
Climate:
  - Earth's temperature and greenhouse effect.
  - Paleoclimate and recent climate changes.
  - The Indian monsoon system.
- Biosphere: Water cycle, Carbon cycle, Nitrogen cycle, Phosphorous cycle. The role of cycles in maintaining a steady state.

#### Unit IV: Evolution:

Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time

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## AREA ELECTIVE I

### Nanostructured Materials and Processing

#### Unit I

**Synthesis and preparation of Nanomaterials:** Synthesis of bulk nanostructured materials - Sol Gel processing- bulk and nano composite materials - Grinding - high energy ball milling –injection moulding - extrusion - melt quenching and annealing.

#### Unit II

**Synthetic Technique (Physical and Chemical):** Self assembly-Self Assembled Monolayers (SAM) - Vapour Liquid Solid (VLS) approach - Chemical Vapour Deposition (CVD) - Langmuir-Blodgett (LB) films - Spin coating - Templated self assembly Electrochemical approaches: Thin films -Epitaxy - Lithography.

#### Unit III

**One dimensional and Two dimensional nanostructures:** Nanowires and Nanotubes: Evaporation-condensation - Vapor- liquid - solid (VLS) - surface and bulk diffusion – kinetics – growth of various nanowires –control of size –precursors and catalysts - single- and multi- wall CNT - Si nanowires – density and diameter – doping in nanowires

#### References:

1. W. Gaddand, D.Brenner, S.Lysherski and G.J.Infrate (Eds), Handbook of nanoscience, Enggand Technology, CRC Press,2002.
2. G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, ImpericalCollege Press, 2004.
3. J.George, Preparation of thin films, Marcel Dekker, InC., New York, 2005.

## AREA ELECTIVE II

### Paper 4 Nano Mechanics

Unit I: Introduction 10L Two - atom chain mechanics, interaction potentials, external forces, dynamics motion, Three atom chain. Lattice mechanics, Stress and strain.

Unit II: Orthotropic and isotropic materials, crystallines materials. Molecular dynamics: verlet algorithms, Nordsieck/gear predictor-corrector methods, molecular dynamics applications, nanomachines, wear at the nanometer level.

Unit III:

Structure of carbon nanotubes, mechanical properties of carbon nanotubes. Nanomechanical measurement techniques and application: AFM measurements: mechanical properties of CNTs, Nanoindantation.

Unit IV: MEMS fabrication techniques, NEMS fabrication techniques, MEMS/NEMS Motion Dynamics, MEMS Devices and applications, NEMS Devices and applications.

References: 1. Introduction to nanoscience and nanotechnology, CRC Press, Tylor and Francis Group, Boca Raton, G. L. Hornyak, H. F. Tibbals, J. Dutta and J J. Moore.

Introductory Nanoscience: Physical and Chemical Concepts, CRC Press, Tylor and Francis Group, Boca Raton, M. Kuno.

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hybrid solar cells, Current status and future prospects.

### Unit 3

**Fuel Cells:** Polymer membranes for fuel cells, Acid/ alkaline fuel cells, design of fuel cells, Carbon Nanotubes for energy storage, Hydrogen Storage in Carbon Nanotubes, Use of nanoscale catalysts to save energy and increase the industrial productivity.

### References:

1. Solar cells: Operating principles, technology and system applications by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
2. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993.
3. Solis state electronic device, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995.
4. Organic Photovoltaics – Materials, Device Physics and Manufacturing Technologies, (eds. C.Brabec, V. Dyakonov, U. Scherf), 2nd Ed., Wiley-VCH, Germany, 2014.
5. Hand book of Batteries and fuel cells, Linden, McGraw Hill, 1984.

### Paper 2 Nano sensors and devices

#### Unit 1

**Nanosensors:** Introduction to sensors. Characteristics and terminology - static and dynamic characteristics. Micro and nano-sensors, Fundamentals of sensors, biosensor, micro fluids, Packaging and characterization of sensors, Sensors for aerospace and defense.

Organic and inorganic nanosensors.

#### Unit 2

**Nanotechnology enabled devices:** Nanomaterials and nanostructured films, Nanoscale electronic and ionic transport. Sensor for bio-medical applications. Nanoparticle-biomaterial hybrid systems for sensing applications. Gas sensor.

**Unit 3 Biosensors:** Magnetic Nanoparticles for Imaging and Therapy, Photodetectors, Nanophotonics. Nanoelectronic Devices. Biosensors, Clinical diagnostics, generation of biosensors. Nanomaterial based biosensors. Biosensors based on nucleotides and DNA. Electron transfer of biomolecules.

### References

1. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester, 2002.
2. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
3. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
4. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.

*Expt 1*  
*Dr. K. K.*  
*Dr. K. K.*

## References:

1. Environmental Chemistry for a Sustainable World, Volume 1: Nanotechnology and Health Risk Editors: Lichtfouse, Schwarzbauer, Robert
2. Advances in Nanotechnology and the Environment, Juyoung Kim, CRC Press, Taylor and Francis Group.

## Paper 3 Nanomaterial synthesis

### Unit 1

**Synthesis and preparation of Nanomaterials:** Synthesis of bulk nanostructured materials - Sol Gel processing- bulk and nano composite materials - Grinding - high energy ball milling – injection moulding - extrusion - melt quenching and annealing.

### Unit 2

**Synthetic Technique (Physical and Chemical):** Self assembly-Self Assembled Monolayers (SAM) - Vapour Liquid Solid (VLS) approach - Chemical Vapour Deposition (CVD) - Langmuir-Blodgett (LB) films - Spin coating - Templated self assembly Electrochemical approaches: Thin films -Epitaxy - Lithography.

### Unit 3

**One dimensional and Two dimensional nanostructures:** Nanowires and Nanotubes: Evaporation-condensation - Vapor- liquid - solid (VLS) - surface and bulk diffusion – kinetics – growth of various nanowires –control of size –precursors and catalysts - single- and multi-wall CNT - Si nanowires – density and diameter – doping in nanowires

## References:

1. W. Gaddand, D. Brenner, S. Lysherski and G. J. Infrate (Eds), Handbook of nanoscience, Engg. and Technology, CRC Press, 2002.
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, properties and applications, Imperial College Press, 2004.
3. J. George, Preparation of thin films, Marcel Dekker, Inc., New York, 2005.
4. C. N. R. Rao, A. Muller, A. K. Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH Verlag GmbH & Co, Weinheim, 2004.

## SEM VI

## Paper 1 Nanoscience in energy conversion and storage

### Unit 1

**Renewable Energy:** Energy conversion process. Introduction to Semiconductor physics, Conducting and semiconducting materials, Semiconductor nanostructures, electronic structure and physical process, material aspect of solar cells, Thin film solar cells, Solar cell characteristics and characterization techniques. Nano-, micro-, and poly crystalline and amorphous Si for solar cells, Si deposition techniques.

### Unit 2

**Plastic/flexible solar cells:** Organic solar cells, Polymer composites for solar cells, p-n junction, Device fabrication and characterization, Nanomaterials for solar cells, Dye-sensitized solar cells, Organic-inorganic

Size Effect: Quantum confinement, Nanomaterials structures, Quantum well, Quantum wire and Quantum dot, Fabrication techniques.

Unit 3 Characterization techniques of Nanomaterials: Determination of particle size, XRD (Scherrer's formula), Increase in width of XRD peaks of nanoparticles, Shift in absorption spectra peak of nanoparticles, shift in photoluminescence peaks, Electron microscopy: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe microscopy (SPM), Scanning Tunneling Electron Microscopy (STEM) and Atomic Force Microscopy (AFM).

Unit 4

Synthesis of Nanomaterials: Key issues in the synthesis of Nanomaterials, Different approaches of synthesis, Top down and Bottom up approaches, Cluster beam evaporation, Ball Milling, Chemical vapor deposition, capping agents, Carbon nanotubes (CNT)- Synthesis, Properties and Applications.

References Books

Nanostructures & Nanomaterials, Synthesis, Properties & Applications by Guozhong Cao, Imperial College Press.

Introduction to Nanotechnology, by Charles P. Poole, Jr. Frank J. Owens, John Wiley & Sons Inc. Publication.

Quantum Wells, Wires and Dots by Paul Harrison, John Wiley & Sons Ltd. Quantum Dot Hetrostructures, by D. Bimberg, M. Grundman, N.N. Ledestov.

Introduction to Nanoscience and Nanotechnology by Hornyak G.L., Tibbals H.F., Dutta J., Moore J.J., CRC Press.

## **Paper 2 Environmental applications of Nanomaterials**

### **Unit I**

**Environment Related Case Studies on Nanomaterials:** Screening of nanomaterials for understanding potential effects to human health and the environment. Mapping of the environmental fate of nanomaterials. Relationships between key properties of nanomaterials and their environmental fate, transport, transformation, bio-distribution, toxicity.

### **Unit II**

**Environmental Pollution by Nanoparticles:** Health impact, safety and toxicological effects transport of nanomaterials in soil/sediments. Study of physical and chemical properties of nanomaterials influencing their behavior in the environment and in biological systems.

### **Unit III**

**Application to Environment:** Nanotechnology for waste reduction and improved energy efficiency, nanotechnology based water treatment strategies. Nanoporous polymers and their applications in water purification, Nanotoxicology.

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1. Nanotechnology; Principals and Practices by Sulabha K. Kulkarni, (2009 Revised edition), Capital Publishing company, New Delhi.
2. Biological Nanostructures and Application of Nanostructures in Biology by Michael A. Strosio and Mitra Dutta (2004) , Kulwer Academic Publishers,
3. Biochemistry: 7th Edition, (2012), Jeremy Berg, Lubert Stryer, W.H. Freeman and company, NY
4. R. Ian Freshney. Culture of Animal cells, 5rd Edition, 2010. A John Wiley & Sons, Inc., Publications, USA

### Nano chemistry

UNIT I- SIZE EFFECTS ON STRUCTURE AND MORPHOLOGY OF NANOPARTICLES (9 hours)  
 Fundamental Properties - Size Effects on Structure and Morphology of Free or Supported Nanoparticles - Size and Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress - Effect on the Lattice Parameter - Effect on the Phonon Density of States- Nanoparticle Morphology - Equilibrium Shape of a Macroscopic Crystal – Equilibrium Shape of Nanometric Crystals - Morphology of Supported Particles UNIT II– SUPERPLASTICITY AND REACTIVITY OF METAL NANOPARTICLE (9 hours)  
 Superplasticity – Introduction – Mechanism - Superplastic Nanostructured Materials - Industrial Applications .Reactivity of Metal Nanoparticles – Size Effects-Structural Properties - Electronic Properties - Reactivity in Chemisorption and Catalysis of Monometallic Nanoparticles – Support Effects - Alloying Effects - Effect of Surface Segregation - Geometric Effects -Electronic Effects- Preparation and Implementation in the Laboratory and in Industry. UNIT III – SUPRAMOLECULAR CHEMISTRY (9 hours) Supramolecular Chemistry: Applications and Prospects - From Molecular to Supramolecular Chemistry – Molecular Recognition - Anionic Coordination Chemistry and Recognition of Anionic Substrates - Multiple Recognition Applications and Prospects. UNIT IV - SUPERCRITICAL FLUIDS (9 hours) Supercritical Fluids – Introduction – Physicochemical Properties – Solubility - Viscosity - Diffusion -Thermal Conductivity - Applications – Purification and Extraction - Synthesis UNIT V– FEATURES OF NANOSCALE GROWTH (9 hours) Specific Features of Nanoscale Growth – Introduction - Thermodynamics of Phase Transitions Dynamics of Phase Transitions - Thermodynamics of Spinodal Decomposition - Thermodynamics of Nucleation – Growth – Size Control - Triggering the Phase Transition- Application to Solid Nanoparticles - Controlling Nucleation - Controlling Growth - Controlling Aggregation. Stability of Colloidal Dispersions - Breaking Matter into Pieces . Learning Resources Sl. No. Reference Books/Other Reading Material 1. C. Brechignac, P. Houdy, M. Lahmani, “Nanomaterials and Nanochemistry”, Springer publication 2007. 2. Kenneth J. Klabunde, “Nanscale materials in chemistry”, Wiley Interscience Publications 2001 3. C. N. Rao, A. Muller, A. K. Cheetham ,“Nanomaterials chemistry”, Wiley-VCH 2007.

### Sem V

Paper 1: Physics of nanomaterials

Unit 1

Introduction to Nanostructure Materials: Nanoscience & nanotechnology, Size dependence of properties, Moor's law, Surface energy and Melting point depression of nanoparticles, Free electron theory (qualitative idea) and its features, Idea of band structure, insulators, semiconductors and conductors, Energy band gaps of semiconductors, Effective masses and Fermi surfaces, Localized particles, Donors, Acceptors and Deep traps, Mobility, Excitons, Density of states, variation of density of states with energy and size of crystal. Quantum Unit2

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1999. The Cell- A Molecular Approach  
 9. Immunology 5th ed Janis Kuby, W.H. Freeman & Co Ltd; 5th Revised edition.  
 10. Essential Immunology, Ivan M. Roit (1994)- Blackwell Scientific Pub, Oxford.  
 11. Cellular and Molecular Immunology, 3rd ed, Abbas, Saunders; 7 edition (11 June 2011)

**Paper 3 Characterization Techniques of Nanomaterials**

**Unit I**

Introduction to spectroscopy Basic principles and applications of UV-Vis-NIR, FTIR, FT-Raman, Photoluminescence, NMR, ESR and Light Scattering methods.

**Unit II X-ray techniques** X-ray powder diffraction –Quantitative determination of phases; Structure analysis, single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis - particle size analysis using Scherer formula- Particle Size Analyzer- Ellipsometry- thickness measurements

**Unit III Electron Spectroscopy** X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials – EDAX and WDA analysis – EPMA - Applications to nanomaterials characterization

**Unit IV Mechanical, Magnetic and electrical properties measurement** Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of Nanoindentation load-displacement curves- Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation. Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of nanomaterials.

- References: 1. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977  
 2. Transmission Electron Microscopy: A Textbook for Materials Science David B Williams, C Barry Carter, (1996) Plenum Press, New York  
 3. Impedance Spectroscopy: Theory, Experiment, and Applications, E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.  
 4. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC Press  
 5. Nanoindentation, By Anthony C Fischer-Cripps, Anthony C. , Springer science and Business media

**Paper 4 Nanobiotechnology**

**Unit I: Biomolecules: (10L)**

Fundamental concepts of biomolecules and their importance in living system, Proteins, Amino acids as building blocks, their types. Nucleic acids- DNA, RNA, their functions, Carbohydrates- Monosaccharides, disaccharides, oligosaccharides, polysaccharide, lipids and fats as biomolecules and Biopolymers. nucleotides and fatty acids as building blocks of biomolecules, Concept of biomolecules as nano-assemblies (10L)

**Unit II: Immune system: (8L)**

Overview of immune system, innate and adaptive immunity, cells and organs of immune system, hematopoiesis, cells of the immune system, organs of the immune system, systematic evolution of immune system. Antigen: Introduction to the concept of immunogenicity, antigenicity, Antibody: Basic structure of antibody, antibody classes and biological activities.

**Unit III: Signalling at cell surface: (7L)**

Signaling molecules and cell-surface receptors, intracellular signal transduction, G protein-coupled receptors that activate or inhibit adenylyl cyclase, regulate ion channels, phospholipase c. Activation of gene transcription by G protein-coupled receptors.

**Unit IV: Biomedical applications: (12L)**

Concept of disease, metabolic disorder, Introduction to cancer, concept of drugs, drawbacks of conventional drug delivery/administration system. Importance of targeted drug delivery system. Essential components of targeted drug delivery system. Biological Nanomaterials: Introduction to concept of biopolymers; Copolymer, Block Copolymers, Micelles, Dendrimers, Hydrogels and their applications. Supramolecular structures; DNA wires and Dendrimers. Importance and application of biologically synthesized nanomaterials. Biomedical applications of gold and silver and other metal nanoparticles and nano materials. Methods of testing antimicrobial activity- well diffusion method, paper disc method, contact inhibition method. Other biomedical applications of nanomaterials.

**References:**

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1. Digital Integrated Circuits: A Design Perspective, Jan M. Rabaey, Prentice-Hall of India
2. Modern Digital Electronics, R. P. Jain, Tata McGraw Hill
3. Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications: Mitin VV, Kochelap VA, Stroschio MA, Cambridge University Press.

#### Paper 4 Nanophysics

##### Unit I

Classical Physics at the Nanoscale: Mechanical Frequency, Viscosity, Brownian Motion of Nanoscale Objects, Motion at the Nanoscale.

##### Unit II

Basics of Quantum Mechanics, Differential Equations of Wave Mechanics, Background of Quantum Mechanics, Development of New Quantum Theory, Quantum Mechanical Way: The Wave Equations, The Wave Function, Energy Bands, Metals, Insulators and Semiconductors.

##### Unit III

Introduction to Optics, Interactions of Light with Matter, Surface Plasmon Resonance, Scattering, Color Generation from Nanoparticles and Nanostructures, Quantum Dots: Tuning the Gap, Luminescence; Photonics, Photonic Structures in Living Systems, Photonic Crystals, Fabrication of Nanophotonic Crystals.

##### Unit IV

Magnetic Phenomena and Their Classical Interpretation, Characteristics of Nanomagnetic Systems, Introduction to Nanomagnetism, Characteristics of Nanomagnetic Materials. Magnetization and Nanostructures, Magnetism in Reduced Dimensional Systems, Physical Properties of Magnetic Nanostructures.

##### References:

1. Science at the Nanoscale, Chin Wee Shong, Sow Chornghaur, Andrew T S Wee, Pan Stanford Publishing Pte. Ltd., Singapore, 2010
2. Introduction to Nanoscience, S. M. Lindsay, Oxford university press, New York, 2010
3. Introduction to Micro- and Nanooptics, Jürgen Jahns and Stefan Helfert, WILEY-VCH Verlag GmbH & Co. KGaA, Germany, 2012
4. Advanced Physics of Electron Transport in Semiconductors and Nanostructures, Massimo V. Fischetti, William G. Vandenberghe, Springer International Publishing, Switzerland 2016

#### Sem IV

##### Paper 1 Material science

##### Unit I

Crystal Structure and crystal defects, Structure of Matter- Amorphous, crystalline, crystals, polycrystals, symmetry, Unit Cells, Crystal Structures (Bravais Lattices), Crystallographic Directions, Crystallographic Planes, Miller Indices, Chemical Bonding- Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and Vander Waals bond; Hybridisation; Hbonding. Crystal defects

##### UNIT II

Conducting and Semiconducting Materials Draw backs of classical theory – Fermi distribution function – Density of energy states(derivation) – effect of temperature on Fermi energy (Qualitative), Origin of band gap in solids (qualitative treatment only) – Concept of effective mass of electron and hole – Law of mass action – Carrier concentration in an intrinsic semiconductor (derivation) – electrical conductivity – band gap determination – Carrier concentration in n-type and p-types semiconductors (Qualitative) – Variation of Fermi level with temperature and impurity concentration (Qualitative) – Hall effect – Determination of Hall coefficient.

##### UNIT III

Magnetic and Dielectric Materials Origin of magnetic moment – Bohr magneton – Weiss theory of paramagnetism, ferromagnetism – Domain theory of ferromagnetism, Hysteresis – Ferrites – magnetic

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recording and readout – Storage of data – Tapes and floppy - magnetic disk drives. Dielectric materials: Electronic, Ionic, Orientational, Spontaneous and space charge polarization – Complex dielectric constant RC equivalent network – dielectric loss – different types of dielectric breakdown — Classification of insulating materials (qualitative)

Unit IV Thermal, Optical and Mechanical Properties of materials Heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses Optical Properties Basic concepts. Optical properties of metals. Optical properties of non metals. Application of optical phenomena. Mechanical Properties of Materials - Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves, Yielding under multiaxial stress. Yield criteria and macroscopic aspects of plastic deformation.

References: 1. Elements of Solid state Physics, by J.P. Srivastava, Prentice Hall of India Private Limited.

2. Introduction to Solid State Physics, by Charles Kittel, Seventh Edition.

3. Solid state Physics, by S.O.Pillai, New Age international Publishers

4. Materials Science and Engineering, by V. Raghavan, Fourth Edition

5. Introduction to Solid State Theory, by Madelung

6. Quantum theory of Solid State, by Callaway,

7. Quantum theory of Solid State, by Kittel

#### Paper 2 Advance Quantum Mechanics

**Unit I:** Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions;

Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions.

**Unit II:** Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states

**Unit III:** General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

**Unit IV:** Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wave functions from Frobenius method; shapes of the probability densities for ground and first excited states;

Orbital angular momentum quantum numbers  $l$  and  $m$ ; s, p, d, shells.

#### References:

1. Nanotechnology; Principals and Practices by Sulabha K. Kulkarni, (2009 Revised edition), Capital Publishing company, New Delhi.
2. Biological Nanostructures and Application of Nanostructures in Biology by Michael A. Strosio and Mitra Dutta (2004), Kulwer Academic Publishers,
3. Biochemistry: 7th Edition, (2012), Jeremy Berg, Lubert Stryer, W.H. Freeman and company, NY
4. R. Ian Freshney. Culture of Animal cells, 5rd Edition, 2010. A John Wiley & Sons, Inc., Publications, USA.
5. E. E. Conn and P. K. Stumpf, Out lines of Biochemistry, John Wiley & Sons, New York.
6. L. Lehninger, Principles of Biochemsitry, CBS Publishers and Distributors.
7. Molecular Biology of the Cell Alberts, Bruce; Johnson, Alexander; Lewis, Julian; Raff, Martin; Roberts, Keith; Walter, Peter New York and London: Garland Science;
8. Molecular Cell Biology 4th ed., Lodish, Harvey; Berk, Arnold; Zipursky, S. Lawrence; Matsudaira, Paul; Baltimore, David; Darnell, James E., New York: W. H. Freeman & Co.,

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5. Principles Physical chemistry, puri B R , Sharma L R, and Madan S P, visal publishing company, Jhlandhar.
6. Biophysical chemistry, Upadhyay A, Upadhyay K, and Nirmala Nath, First edition, Himalaya Publishing Company Mumbai.

#### Additional

#### References

##### 1. Biophysics-

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2. Principles of biochemistry- A L Lehninger.

3. Biophysics-Upadhay

### Sem III

#### Paper 1 Nanomaterials

##### Unit I

Electronic Properties Introduction, Properties of materials & nanomaterials, role of size in nanomaterials. Electronic Properties, Electronic materials, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects, Confinement and transport in nanostructure. Ballistic transport, Coulomb blockade, Resonant Tunnelling.

##### Unit II

Magnetic and Dielectric properties Brief review on Dia, Para, Ferromagnetic materials, Superparamagnetism and its limit. Important properties in relation to nanomagnetism-GMR, TMR, Transport in a magnetic field, Quantum Hall Effect, spin value, spin tunnelling junctions- size induced magnetism on Au and Ag nanoparticles-Dielectric properties- Effect of particle size on dielectric properties, Ferroelectrics and multiferroics.

##### Unit III

Optical Properties Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence, Band gap engineering, Size effect of metal Nano particles, Surface Plasmon resonance phenomena, optical properties of semiconductor nanoparticles.

##### Unit IV

Mechanical Properties Micro hardness- nanoindentation- fracture toughness- superplasticity- plastic nature of nanoceramics- nanomembrances-inter connected pores - Bulk nanostructured materials influence of porosity. Hall-Petch relation, microstructure – dislocation interactions at low and high temperatures; effects of diffusion on strength and flow of materials; methods of enhancing or retarding diffusion; grain boundary sliding and grain boundary migration.

References : 1. Novel Nanocrystalline Alloys and Magnetic Nanomaterials- Brian Cantor

2. Nanomaterials Handbook- Yury Gogotsi

3. Encyclopedia of Nanotechnology- Hari Singh Nalwa

4. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens

5. Physical Theory of Magnetic Domains - C. Kittel 6. Robert E. Newnham, Properties of materials, Oxford university press, 2005 7. Wole Soboyejo, Mechanical properties of engineered materials, Marcel Dekker Inc., 2002.

#### Paper 2 Thermal Physics

**Unit I:** Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between  $C_p$  and  $C_v$ , Work Done during

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Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

**Unit II:** Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2<sup>nd</sup> Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

**Unit III:** Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature-Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

**Unit IV:** Thermodynamic Potentials: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations

**Reference Books:**

Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill. A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press  
Thermal Physics, S. Garg, R. Bansal and Ghosh, 2<sup>nd</sup> Edition, 1993, Tata McGraw-Hill Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger 1988, Narosa.  
Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

**Paper 3 Nanoelectronics**

**Unit I: Digital Integrated Circuits**

Digital integrated circuits: Logic levels, propagation delay time, power dissipation fan-out and fan-in, noise margin, logic families and their characteristics Diode-transistor logic (DTL), Transistor-transistor logic (TTL), Emitter-coupled logic (ECL) and Complementary metal-oxide-semiconductor logic (CMOS) integrated circuits and their performance comparison, open collector and tristate gates and buffers.

**Unit II: Introduction to CMOS Integrated Circuits**

Manufacturing CMOS Integrated Circuits: The Silicon Wafer, Photolithography technique, Some Recurring Process Steps, Simplified CMOS Process Flow, Packaging Integrated Circuits: Package Materials, Interconnect Levels, Thermal Considerations in Packaging, Perspective — Trends in Process Technology, Short-Term Developments and Long Term Developments.

**Unit III: Nanoelectronics Devices I**

Introduction: P-type metal-oxide-semiconductor (PMOS), N-type metal-oxide-semiconductor logic (NMOS), and CMOS, Resonant-tunnelling diodes: The physics underlying the resonant-tunnelling effect, Quantitative characteristics of the resonant tunnelling effect, Sequential tunnelling, Negative differential resistance under resonant tunnelling. Field-effect transistors: Devices controlled by the field effect, The Field-effect transistor (FET) family devices, and introduction to Nanowire FETs and single electron transistors.

**Unit IV: Nanoelectronics Devices II**

Light-emitting diodes and lasers: Photon absorption and emission, Interband emission and absorption in semiconductors, Laser diodes, Light-emitting diodes. Introduction to Microelectromechanical systems (MEMS) and Nanoelectromechanical systems (NEMS), Advantages of NEMS over MEMS, Introduction to Quantum-dot cellular automata.

**References:**

Handwritten signatures and initials in blue ink, including a large 'M' and other illegible marks.

effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

#### Reference Books:

Introduction to Solid State Physics, Charles Kittel, 8<sup>th</sup> Edn. 2004, Wiley India Pvt. Ltd. Elements of Solid State Physics, J.P. Srivastava, 2<sup>nd</sup> Edn., 2006, Prentice-Hall of India. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.  
Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.  
Solid State Physics, Rita John, 2014, McGraw Hill  
Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Paper 4: Basics Circuits fundamentals

#### UNIT - I

Growth and decay of currents through inductive resistances, charging and discharging in R.C. and R.L.C. circuits, Time constant, Measurement of high resistance. A.C. Bridges, Maxwell's and Scherings Bridges, Wien Bridge. THEVENIN, NORTON and Superposition theorems and their applications.

#### UNIT - II

Semiconductors, intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, unbiased diode forward bias and reverse bias diodes, diode as a rectifier, diode characteristics, zener diode, avalanche and zener breakdown, power supplies, rectifier, bridge rectifier, capacitor input filter, voltage regulation, zener regulator.

Bipolar transistors, three doped regions, forward and reverse bias, DC alpha, DC beta transistor curves.

#### UNIT - III

**Transistor biasing circuits:** base bias, emitter bias and voltage divider bias, DC load line.

Basic AC equivalent circuits, low frequency model, small signal amplifiers, common emitter amplifier, common collector amplifiers, and common base amplifiers, current and voltage gain, R.C. coupled amplifier, gain, frequency response, equivalent circuit at low, medium and high frequencies, feedback principles.

#### UNIT - IV

Input and output impedance, transistor as an oscillator, general discussion and theory of Hartley oscillator only. Elements of transmission and reception, basic principles of amplitude modulation and demodulation. Principle and design of linear multimeters and their application, cathode ray oscillograph and its simple applications.

**Course Outcome(s):** After completion of this course students would be able to

1. To understand and learn the Mechanical Properties, Thermal Properties, Electrical Properties, and Magnetic Properties of materials.
2. To understand the basic concept of Dislocations and Plastic Deformation.
3. To understand Atomic Diffusions and its Mechanism.
4. To state Fick's Law (Ist and IInd Law).
5. To understand basics of phase diagram, its classifications, and its interpretation.

#### Text and Reference Books

B.G. Streetman; "Solid State Electronic Devices", IInd Edition (Prentice Hall of India, New Delhi, 1986).  
W.D. Stanley: "Electronic Devices, Circuits and Applications" (Prentice-Hall, New TTC'A 1f100\JL4y, JJI. 100).  
J.D. Ryder, "Electronics Fundamentals and Applications", II<sup>nd</sup> Edition (Prentice-Hall of India, New Delhi, 1986).

J Millman and A Gabel, "Microelectronics", International Edition (McGraw Hill Book Company, New York, 1988).

## BIOPHYSICS

Aim: To introduce the fundamentals of biophysics and biological importance of various physical and chemical phenomena

### UNIT I

Laws of thermodynamics, Basic concept of enthalpy, entropy and free energy. chemical kinetics

- rate, order, molecularity of reactions and energy of activation. Chemical kinetics- Order and Molecularity. Buffers-acidic and basic buffers. p H -meter and scale. Interaction of acids with base.

### UNIT II

Properties of solution-Types of solution, characteristics of true solution. Concentration UNITS; Normality, Molarity, and Molality. Colloids- types, properties and its separation techniques. Donnan equilibrium. Adsorption and Absorption. Emulsions.

### UNIT III

Dynamics of biomolecules: Diffusion, Laws of diffusion, Active transport, Facilitated diffusion, Osmosis, Osmotic pressure, Osmoregulation, Viscosity and biological importance, Surface tension, Factors influencing surface tension. Dialysis.

### UNIT IV

Radioactivity-Types and UNITS. Types of radiation. Radioactive decay. Applications of Radioisotope in science. Detection and measurement of radioactivity.-Ionisation counter, G M counter and Liquid scintillation counter. Applications in Biology-. X-ray crystallography and Auto radiography.

### Practical

1. Microscopy, Resolving power and measurement of numerical aperture
2. Determining solution concentration using absorption spectrophotometer
3. Measurement of Blood Pressure
4. Measurement of the Blood flow velocity
5. Study of absorption spectrum of chlorophylls
6. Effect of electrolyte and non-electrolyte concentration on membrane permeability
7. To calculate the Normality, Molarity, and Molality of the solution

### REFERENCES

4. Introduction of Biophysics-Pranab Kumar Banerjee

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## UNIT -I:

### Limit and continuity of real valued function

Definition of limit of function of one variable, Left Hand side limit and right hand side limits. Theorems on limit (only statement), Continuous function and their properties. Classification of discontinuity. (First kind and second kind) and types of discontinuities. a) Removable discontinuity b) jump discontinuity of first kind and second kind. Differentiability of a function.  $\sin x, \cos x e^x, \log (1+x)^m, \sin (ax+b) e^x, \cos (ax+b) e^x$

## Unit - II :

L'Hospital Rule, the form and examples, L'Hospital rule the form and examples. L'Hospital Rule the form and examples, Maxima and minima for function of two variables.

**Unit III:** Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions.

**Unit IV:** Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1<sup>st</sup> and 2<sup>nd</sup> order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2<sup>nd</sup> order Differential Equations.

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**Reference books:**

1. Differential calculus Shanti Narayan, DR. P.K. Mittal; S Chand Pub
2. A Textbook of calculus and differential equations H. T. Dinde, A. D. Lokhande
3. A Textbook of Advanced Calculus.
4. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc., 2002.
5. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2007.
6. Jamnadas and Com. Bombay, 1982

**Paper 2: Introductory Chemistry**

**Unit I** Chemical Equilibria - Activity concept, equilibrium constant and applications, ionisation constants of acids and bases. Concept of pH, hydrolysis of salts, Buffers – types, range and capacity, dissociation of polyprotic acids, common ion effect, salt effect. Electrochemistry – Conductivity of electrolytes, electrochemical cells, standard electrode potentials

**Unit II** Symmetry and Group theory, Bonding models in chemistry – ionic bond, covalent bond, Coordination Chemistry - Theories of bonding in coordination compounds and electronic spectra of coordination compounds

**Unit III** Thermodynamics: First, second and third law of thermodynamics. Gibbs and Helmholtz energy and chemical equilibrium. Chemical kinetics, Transition state theory and collision theory, Heterogeneous catalysis.

**Unit IV** Organic compounds – Structure and bonding, aliphatic and aromatic compounds, functional groups, nucleophiles and electrophiles, reactions and mechanisms

**References:**

1. Fundamentals of Analytical Chemistry - Skoog, West and Holler, Saunders College Publishing, VI Edition, 1991, and VII Edition, 1996.
2. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, VI Edition, Pearson Education Ltd, 2001.
4. Inorganic Chemistry – Principles of structure and Reactivity – J.E. Huheey, E.A. Keiter and R.L. Keiter, IV Edition
5. Physical chemistry Atkins
6. Physical Chemistry, .A. Alberty and R.J. Silbey

**Paper 3: Introduction to solid state physics**

**Unit I:** Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis– Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

**Unit II:** Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids.  $T^3$  law.

**Unit III:** Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia- and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

**Unit IV:** Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. ClausiusMosotti Equation. Classical Theory of Electric Polarizability. Langevin-Debye equation.

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner

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## **Paper 2: Introduction to Nanoscience and Nanotechnology**

### **Unit I**

Background to Nanoscience: Definition of Nano, Scientific Revolution-Atomic Structure and atomic size, emergence and challenges of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties.

**Unit II** Types of nanostructure and properties of nanomaterials: One dimensional, Two dimensional and three-dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

**Unit III** Application of Nanomaterial: Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, membrane-based application, polymer-based application.

### **References:**

1. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
2. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
3. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.
4. Processing & properties of structural naomaterials - Leon L. Shaw Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

## **II Sem**

### **Comprehension & Communication Skills in English-II**

#### **UNIT I: Grammar Topics**

- Preposition & Prepositional Phrase
- Simple, Compound, Complex Sentences
- Clauses: Finite & Non-finite Clauses
- Direct and Indirect Speech
- Degrees of Comparison

#### **UNIT II: Conversational English: Tele-manners & Situational Dialogues**

- Asking for someone
- Dealing with wrong numbers
- Taking and Leaving Messages
- Making Inquiries/Calling for Help in an Emergency
- At the Bank/ At an Office

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- At the Railway Station/Airport
- At a hotel

### UNIT III: Conversational English: Vocabulary /Idioms

- Common idioms and phrases
- Idioms and phrases from Science and Technology
- Word Power: How to talk about science and scientists (From Word Power Made Easy by Norman Lewis: Sessions 11–13)
- Inaccurate, misleading, misused, ambiguous, and logically confused words and phrases in Psychology, Science and Technology

### UNIT IV: An Introduction to English Phonology

- Syllable
- Word Accent and Rules
- Accent and rhythm in connected speech, Strong and weak forms
- Intonation (Rising and Falling)

### UNIT V: Communication skills

- Channels of communication
- Verbal and Non-Verbal communication, Formal and Informal communication
- Non-Verbal communication- Kinesics & Proxemics, Paralanguage,
- Barriers of, and aids to communication.

#### Practical

1. Listening Comprehension: Listening to short talks lectures, speeches (scientific, commercial and general in nature).
2. Oral Communication: Phonetics, stress and intonation, Conversation practice.
3. Conversation: rate of speech, clarity of voice, speaking and Listening, politeness & Reading skills: reading dialogues, rapid reading, intensive reading, improving reading skills.
4. Mock Interviews: testing initiative, team spirit, leadership, intellectual ability.  
Group Discussions

**Paper Name: Differential calculus and complex analysis**

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### Reference Books :

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al., Tata McGraw-Hill 2007.
3. Physics, Resnick, Halliday and Walker, Wiley publications 8<sup>th</sup> edition. 2008.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday., Cengage Learning 2005.
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, Pearson Education, 2008.
6. University Physics, Ronald Lane Reese, Thomson Brooks/Cole, 2003.
7. Additional Books for Reference Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000.
8. University Physics. F.WSears, M.WZemansky, H.D Young Addison Wesley 13<sup>th</sup> edition , 1986.
9. Mathematical physics .B.S. Rajput Pragati publication, 30<sup>th</sup> edition 2011.

### Paper Name: Atomic Structure and Bonding

#### Unit : I

#### Introduction to quantum Chemistry & atomic structure

Black Body radiation, photo electric effect, Compton effect, plank's theory, De Broglie's relationship, experimental verification of wave nature of electron, Schrodinger wave equation (no derivation expected), significance of wave function, probability distribution of electrons, Bohrs theory of hydrogen atom, quantization of energy, hydrogen spectrum, wave theory, Heisenberg's uncertainty principal, atomic orbital's & quantum numbers, Pauli's exclusion principal, Hund's multiplicity rule, aufbau principals, electronic configuration of elements.

#### Unit - II :

#### Ionic Bonding

Ionic Bonding: General characteristics of ionic bonding, Formation of ionic bond, Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, Born- Haber cycle

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and its applications, Fajan's rules, Radius ratio effect on geometry, calculation of radius ratio for ionic solid with octahedral geometry, Crystal structure of rock salt, CsCl, ZnS.

### Unit - III :

#### Covalent bonding

Introduction, Lewis theory, VB Approach, of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements, Concept of resonance and resonating structures in various inorganic and organic compounds.

### Unit - IV :

#### Molecular orbital theory

MO Approach: Rules for the LCAO method, bonding and antibonding. MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing)  $N_2$ ,  $N_2^+$ ,  $N_2^-$ ,  $O_2^+$ ,  $O_2^-$  and heteronuclear diatomic molecules such as CO, NO. Comparison of VB and MO approaches.

#### Reference Books:

1. Principles of Inorganic Chemistry; By Puri, Sharma & Kalia, Vishal publication. Co., 33rd ed., 2017.
2. Inorganic Chemistry Gulati Shikha, Sharma Gulati JL and Manocha, Shagun, 1st Edn., CBS Publishers & Distributors, (2017)
3. Valency and Bonding. Weinhold, F.; Landis, C. Cambridge. (2005)
4. Quantum Chemistry; By R. K. Prasad, New Age Publication. 2006
5. Principles of Structure and Reactivity; By James H. Huheey, Keiter, Medhi; 4th edition Pearson Education India, 2006.
6. Concise Inorganic Chemistry Lee J. D, Wiley India, 5th Edn., 2008.
7. Principles of structure and reactivity, .Huheey J. E., Keiter E. A. and Keiter R. L., Pearson Education, 4th Ed. 2002.

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## **Paper Name: Mechanics and properties of Mater**

### **Unit - I**

#### **Vectors**

Vector algebra, Scalar and vector products, Derivatives of a vector with respect to a Variable (velocity and acceleration).

### **Unit-II**

#### **Laws of Motion:**

Frames of reference, Newton's Laws of motion (with proof). Motion at nanoscale, problems, etc.

#### **Momentum and Energy:**

Conservation of linear and angular momentum, work and energy theorem, conservation of energy (Single particle), Dynamics of a system of particles (linear momentum, angular momentum and energy), Centre of mass, Motion of rockets (qualitative treatment only). problems, etc.

### **Unit - III**

#### **Rotational Motion:**

Angular velocity, angular momentum and Torque, Kinetic energy of rotation and moment of Inertia, Moment of inertia of a spherical shell, solid cylinder (only about axis of symmetry), Motion of spherical Shell and solid cylinder rolling down on an inclined plane. Problems, etc.

### **Unit IV**

Simple harmonic motion, Differential equation of SHM and its solutions, Kinetic and Potential Energy, Total Energy and their time averages, Damped oscillations, Forced oscillations, Frequency of nanoscale matters, problems, Surface tension (definition), Angle of contact and wettability, Relation between surface tension

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4. Be able to carry out, present and document a comprehensive independent work, demonstrating command of the terminology of the subject area.
5. Identify different special mathematical functions.
6. Apply techniques of vector analysis, such as gradient of scalar, divergence of vector, curl of vector,
7. To the study of special functions of mathematical physics

**Reference Books:**

Mathematical Methods for Physicists, G.B.Arken, H.J.Weber, F.E.Harris, 2013, 7<sup>th</sup>Edn., Elsevier.

An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning Differential Equations, George F. Simmons, 2007, McGraw Hill.

Advanced Engineering Mathematics, D.G. Zill and W.S.Wright, 5 Ed., 2012, Jones and Bartlett Learning

Mathematical Physics, Goswami, 1<sup>st</sup> edition, Cengage Learning

Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

2. Crucial Conversations- Joseph Grenny, Kerry Patterson, Ron McMillan and Al Switzler

Course Name: Mathematical Physics-I | Course Code BNS 102

Credits=L+T+P(4+0+0)

Hours=60

**Objectives:** The emphasis of course is on applications in solving problems of interest to physicists.

The students are to be examined entirely on the basis of problems, seen and unseen.

**Unit I:** Plotting of functions. Approximation: Taylor and binomial series (statements only). First Order Differential. Equations exact and inexact differential equations and Integrating Factor. Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Particular Integral with operator method, method of undetermined coefficients and variation method of parameters.

**Unit II:** Vector Algebra: Properties of vectors. Scalar product and vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

**Unit III:** Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their verification (no rigorous proofs).

**Unit IV:** Orthogonal Curvilinear Coordinates, Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Dirac Delta function: Definition of Dirac delta function and simple examples.

**Course outcomes:** After completion of this course the student will be able to:

1. Have knowledge about, and being able to use, advanced mathematical methods and theories on various mathematical and physical problems.
2. Use mathematical formulations, analyses and models to obtain insight in specialized areas of Physics.
3. Be able to apply skills of mathematical, statistical and physical modeling in applied fields and on technological problems.

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# 1<sup>st</sup> Year, SEMESTER-I

## Comprehension & Communication Skills in English-I

**UNIT I-** War minus Shooting- The sporting Spirit. A Dilemma- A layman looks at science Raymond B. Fosdick.

**UNIT II -** You and Your English – Spoken English and broken English G.B. Shaw. Reading Comprehension, Vocabulary- Antonym, Synonym, Homophones, Homonyms, often confused words.

**UNIT III -** Exercises to help the students in the enrichment of vocabulary based on TOEFL and other competitive examinations.

**UNIT IV -** Functional grammar: Articles, Prepositions, Verb, Subject verb Agreement, Transformation, Synthesis, Direct and Indirect Narration. Written Skills: Paragraph writing, Precise writing, Report writing and Proposal writing.

**UNIT V -** The Style: Importance of professional writing. Preparation of Curriculum Vitae and Job applications. Synopsis Writing. Interviews: kinds, Importance and process.

### Practical

1. Listening Comprehension: Listening to short talks lectures, speeches (scientific, commercial and general in nature).
2. Oral Communication: Phonetics, stress and intonation, Conversation practice.
3. Conversation: rate of speech, clarity of voice, speaking and Listening, politeness & Reading skills: reading dialogues, rapid reading, intensive reading, improving reading skills.
4. Mock Interviews: testing initiative, team spirit, leadership, intellectual ability.  
Group Discussions

### References

1. Difficult Conversation- Bruce Patton, Sheila Heen and Roger Fisher

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NES 2020

Study and Evaluation Scheme (2020)  
B.Sc. (Nanotechnology) V Sem

S.No.	Subject Code	Name of the subject	Periods				Evaluation Scheme		Total Marks	Credit
			Type	L	T	P	CCA	ESE		
<b>THEORY SUBJECT I SEMESTER</b>										
1.	BNS-501	Physics of Nanomaterials	Core	4	0	0	25	75	100	4
2.	BNS-502	Environmental applications of Nanomaterials	Core	4	0	0	25	75	100	4
3.	BNS-503	Nanomaterial synthesis	Core	4	0	0	25	75	100	4
4.	BNS-504	Seminar and Viva voce	Core	2	0	4	50	200	250	4
<b>PRACTICAL I SEMESTER</b>										
6.	BNS-501-P	Lab 1 of Nanomaterials	Core	0	0	2	15	35	50	2
7.	BNS-502-P	Lab 2 of Nanomaterials	Core	0	0	2	15	35	50	2
<b>TOTAL</b>				14		8	155	495	650	22

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NEP 2020

**Study and Evaluation Scheme (2023)**  
**B.Sc. (Nanotechnology) VI Sem**

S.No.	Subject Code	Name of the subject	Periods				Evaluation Scheme		Total Marks	Credit
			Type	L	T	P	CCA	ESE		
<b>THEORY SUBJECT VI SEMESTER</b>										
1.	BNS-601	Nanoscience in energy conversion and storage	Core	4	0	0	25	75	100	4
2.	BNS-602	Nano sensors and devices	Core	4	0	0	25	75	100	4
<i>Note:-To be selected only one course from the following elective courses</i>										
3.	<b>AREA ELECTIVE</b>									
	BNS-603 A	Nanostructured materials	Core	4	0	0	25	75	100	4
	BNS-603 B	Nano Mechanics	Core							
	BNS-603 C	Physics of Earth	Core							
BNS-603 D	Applications of Nanomaterials	Core								
4.	BNS-604	Project & Viva	Core	2	0	6	50	250	300	5
<b>PRACTICAL VI SEMESTER</b>										
6.	BBI-601-P	Lab of Nano sensors	Core	0	0	2	15	35	50	2
<b>TOTAL</b>				14		8	140	510	650	19

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NEP 2020  
 Study and Evaluation Scheme (2020)  
 B.Sc. (Nanotechnology) III Sem

S.No.	Subject Code	Name of the subject	Periods				Evaluation Scheme		Total Marks	Credit
			Type	L	T	P	CCA	ESE		
<b>THEORY SUBJECT I SEMESTER</b>										
1.	BNS-301	Nanomaterials	Core	4	0	0	25	75	100	4
2.	BNS -302	Thermal Physics	Core	4	0	0	25	75	100	4
3.	BNS -303	Nanoelectronics	Core	4	0	0	25	75	100	4
4.	BNS -304	Biophysics	Core	4	0	0	25	75	100	4
5.	BNS -105	Nanophysics	Core	4	0	0	25	75	100	4
<b>PRACTICAL I SEMESTER</b>										
6.	BNS-301-P	Lab of Nanomaterials	Core	0	0	2	15	35	50	2
7.	BNS-302-P	Lab of Nano electronics	Core	0	0	2	15	35	50	2
8.	BNS-303-P	Lab of Thermal physics	Core	0	0	2	15	35	50	2
<b>TOTAL</b>				<b>20</b>		<b>6</b>	<b>170</b>	<b>480</b>	<b>650</b>	<b>26</b>

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*Dr. Nivedita*

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NE 2020  
**Study and Evaluation Scheme (2020)**  
**B.Sc. (Nanotechnology) IV Sem**

S.No.	Subject Code	Name of the subject	Periods				Evaluation Scheme		Total Marks	Credit
			Type	L	T	P	CCA	ESE		
<b>THEORY SUBJECT I SEMESTER</b>										
1.	BNS-401	Material science	Core	4	0	0	25	75	100	4
2.	BNS -402	Advance Quantum Mechanics	Core	4	0	0	25	75	100	4
3.	BNS -403	Characterization Techniques of Nanomaterials	Core	4	0	0	25	75	100	4
4.	BNS -404	Nanobiotechnology	Core	4	0	0	25	75	100	4
5.	BNS -405	Nano chemistry	Core	4	0	0	25	75	100	4
<b>PRACTICAL I SEMESTER</b>										
6.	BNS-401-P	Lab of Material science	Core	0	0	2	15	35	50	2
7.	BNS -402-P	Lab of Nano biotechnology	Core	0	0	2	15	35	50	2
8.	BNS-403-P	Lab of Nano chemistry	Core	0	0	2	15	35	50	2
<b>TOTAL</b>				<b>20</b>		<b>6</b>	<b>170</b>	<b>480</b>	<b>650</b>	<b>26</b>

Syllabus under NEP-2020

Keral Verma Subharti College of Science  
Swami Vivekanand Subharti University, Meerut

Bachelor of Science in Nanotechnology

**Annexure - 1**  
**Study and Evaluation Scheme**  
**B.Sc. (Nanotechnology) I Sem**

S.No.	Subject Code	Name of the subject	Periods				Evaluation Scheme		Total Marks	Credit
			Type	L	T	P	CCA	ESE		
<b>THEORY SUBJECT I SEMESTER</b>										
1.	BNS-101	Comprehension & Communication Skills in English-I	AECC	4	0	0	25	75	100	4
2.	BNS-102	Mathematical Physics	Core	4	0	0	25	75	100	4
3.	BNS -103	Mechanics and properties of Mater	Core	4	0	0	25	75	100	4
4.	BNS -104	Introduction to nanotechnology and nanoscience	Core	4	0	0	25	75	100	4
5	BNS-105	Atomic structure and bonding	core	4	0	0	25	75	100	4
<b>PRACTICAL I SEMESTER</b>										
6.	BNS-101-P	Comprehension & Communication Skills in English Practical-I	AECC	0	0	2	15	35	50	2
7.	BNS -102-P	Lab of basic Nanotechnology	Core	0	0	2	15	35	50	2
8.	BNS -103-P	Lab of Mechanics and properties of Mater	Core	0	0	2	15	35	50	2
<b>TOTAL</b>				<b>20</b>		<b>6</b>	<b>170</b>	<b>480</b>	<b>650</b>	<b>26</b>



*Ekli*  
*(Dr. Ekta Gupta)*

*S. N. Singh*  
*Dr. Nirdeish Anand Singh*  
Head of Physics  
Keral Verma Subharti College of Science  
Swami Vivekanand Subharti University  
Meerut

*Dr. Ismail*  
*Prof*