ACADEMIC YEAR 2022-2024

CENTRE FOR NANO SCIENCE AND TECHNOLOGY

UNIVERSITY COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

COURSE SCHEME AND SYLLABUS (CBCS) FOR

M.TECH (NANOTECHNOLOGY)

OBJECTIVES OF CENTRE FOR NANO SCIENCE AND TECHNOLOGY

- To create a dynamic teaching and research atmosphere that will promote interaction and synergies among the different groups of scientists working in the field of Nanoscience & Nanotechnology.
- To attract researchers from diverse fields of research such as Technology, Applied Sciences as well as Engineering and Medicine. This vibrant environment will attract world-renowned Nanoscience and Nanotechnology researchers.
- To establish facilities that will give researchers access to advanced scientific equipment for characterization and preparation of nanomaterials for Nanotechnology applications.
- To provide a dynamic focal point for the development of future high-tech industries in India.
- The vision of the Centre is to turn students into the future generation of leadership of high technology research and industry in India, and that nanotechnology industries in India to become world leaders in the field.
- To create and provide opportunities for international exchange of scientists and students, and make collaborative arrangements within India, particularly for those who are deprived of such facilities.
- To conduct seminars/workshops/conferences/extension lectures to promote Nanoscience & Nanotechnology.
- The Centre will establish joint collaborative programs with the up-coming industries in the field of Nanotechnology.
- To create and develop world class R&D infrastructure for Nanotechnology.
- To promote collaboration research with scientist in other R&D Institutions and Industry in the Country.
- To provide excellent facilities for talented young students to carry out research projects in Nanotechnology.
- To provide facilities to visiting scholars and faculty from other Institutions in India and abroad.
- To publish monographs and reports on front-line research areas in Nanotechnology.
- To promote international and national collaborations and joint research projects.

Vision:

- The Centre is committed to provide postgraduate academic and research programs to produce high quality human resource with ability to meet the global challenges and to become a world leader in research and teaching of Nano Sciences and Materials to address the local, national and international societal needs for the betterment of mankind and train the young researchers/students for advances in nano and materials technology.

Mission:

- Nanoscience and Technology programme aims to provide quality interdisciplinary science and engineering education with state-of-the-art infrastructural facilities, engaging outstanding scientists from different branches of science and engineering, encouraging them to carry out their individual scientific research, the graduates can advance the frontiers of knowledge in Nanotechnology by developing and transforming them through research and innovations with major thrust on the following areas: sensors, medical nanotechnology, agricultural nanotechnology, nanotechnology based solutions for energy and environment.

Program Educational Objectives (PEO's):

- PEO1: Apply the scientific knowledge of Physics, Mathematics, Chemistry, and Engineering for deeper understanding of the matter at nanoscale.
- PEO2: Identify, formulate, research literature, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- PEO3: Design solutions for advanced scientific problems and design system components or processes.
- PEO4: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- PEO5 :Create, select, and apply appropriate techniques, resources, and modern scientific and IT tools including prediction and modelling to complex engineering activities with an understanding ofthe limitations.
- PEO6: Apply reasoning informed by the contextual knowledge to assess societal, health,safety, legal and cultural issues and the consequent responsibilities relevant to the professional scientific practice.
- PEO7: Communicate effectively on complex Scientific/Technological activities with the Scientific/engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- PEO8:Recognize the need for, and have the preparation and ability to engage in independent and life-long learning.

Programme Outcomes (PO's) :

- PO1:Apply principles of basic science concepts in understanding, analysis and prediction of matter at Nano scale.
- PO2 :To introduce interdisciplinary areas for interdisciplinary application of Science and engineering concepts.
- PO3: To introduce advanced ideas and techniques required in emerging areas in nanotechnology.
- PO4: To develop human resource with specialization in theoretical and experimental techniques required for career in academia and Nano technology driven industry.
- PO5: Engage in lifelong learning and adapt to changing professional and societal needs.

Program Specific Outcomes: (PSO's):

- PSO1: Understand and apply principles of physics, chemistry and engineering for understanding the scientific phenomenon in nano domain.
- PSO2: Understand and apply Theoretical concepts on experimental learning of Nanosystems for describing and deeper understanding.
- PSO3: Provide exposure in various specialization of Nanotechnology
- PSO4: Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of phenomenon at nano scale and nano systems.
- PSO5: Engage in research and life-long learning to adapt to changing environment.

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COURSE SCHEME AND SYLLABUS (CBCS) FOR

M.TECH (NANOTECHNOLOGY)

M.TECH I - SEMESTER

Course Number	Subject	Scheme Of Studies Per Week			Credits	Int Marks	Ext Marks
		L	T	P			
1NTPC01	**Program Core-I** Synthesis and Properties of Nanostructures	3	0	0	3	40	60
1NTPC02	**Program Core-II** Materials Characterization Techniques	3	0	0	3	40	60
1NTPE03	**Program Elective-I** 1.Structure, Bonding and Quantum Mechanics 2.Physics and Chemistry of Materials 3. Photonics (Quantum Confined Materials) 4. Statistical Thermodynamics for Nanosystems 5. Green Nanotechnology	3	0	0	3	40	60
1NTPE04	**Program Elective-II** 1. Nano Biomedical Applications 2. Nano Biotechnology 3. Bio Nanostructures	3	0	0	3	40	60
1A01	Research Methodology & IPR	2	0	0	2	40	60
1A02	**Audit Course-I** 1. English for Research Paper Writing 2. Disaster Management 3. Sanskrit for Technical Knowledge 4. Value Education 5. Constitution of India 6. Pedagogy Studies 7. Stress Management by Yoga 8. Personality Development through Life Enlightenment Skills	2	0	0	0	0	0
1NTL05	Synthesis of Nanomaterials Lab	0	0	4	2	40	60
1NTL06	Fabrication and Characterization of Nanomaterials Lab	0	0	4	2	40	60
	Total Credits:	**16**	**0**	**08**	**18**	**280**	**420**

M.TECH II SEMESTER

Course Number	Subject	Scheme of Studies Per Week			Credits	Int Marks	Ext Marks
		L	T	P			
2NTPC07	**Program Core- III** Nano Sensors and Devices	3	0	0	3	40	60
2NTPC08	**Program Core- IV** Industrial trends and Applications of Nanotechnology	3	0	0	3	40	60
2NTPE09	**Program Elective-III** 1. Nanotechnology for Energy Systems 2. Nano Electronics and Nano Photonics 3. Nano Composites Design and Synthesis 4. Nanotribology	3	0	0	3	40	60
2NTPE10	**Program Elective-IV** 1. Science & Technology of Thin Films 2. Lithographic Techniques 3.MEMS and NEMS Design and Applications	3	0	0	3	40	60
2A03	**Audit Course-II** 1. English for Research Paper Writing 2. Disaster Management 3. Sanskrit for Technical Knowledge 4. Value Education 5. Constitution of India 6. Pedagogy Studies 7. Stress Management by Yoga 8. Personality Development through Life Enlightenment Skills	2	0	0	0	0	0
2NTL11	Nanostructured Material Application Lab	0	0	4	2	40	60
2NTL12	Simulation Lab	0	0	4	2	40	60
2NT13	Mini Project with Seminar	0	0	4	2	50	50
Total Credits:		**14**	**0**	**12**	**18**	**290**	**410**

*Students be encouraged to go to Industrial Training/Internship for at least 2-3 months during semester break

M.TECH III-SEMESTER

Course Number	Subject	Scheme of Studies Per Week			Credits	Int Marks	Ext Marks
		L	T	P			
3NTPE14	**Program Elective -V** 1. NPTEL-12 Weeks 2. Nanotoxicology 3. Societal Impact ofNanotechnology 4. Semiconductor Device Technology	3	0	0	3	40	60
3NTOE15	Open Elective 1. Industrial Safety 2. Waste to Energy 3. Applications of Nanotechnology	3	0	0	3	40	60
3NT16	Dissertation Work Review-I	0	0	0	0	0	0
3NT16	Dissertation Work Review-II	0	0	20	10	50	50
Total Credits:		**06**	**0**	**20**	**16**	**130**	**170**

*Students going for Industrial Project/Thesis may complete these courses through MOOCs/NPTEL/Online.

M.TECH IV-SEMESTER

Course Number	Subject	Scheme of Studies Per Week			Credits	Int Marks	Ext Marks
		L	T	P	C		
4NT17	Dissertation Work Review-III and Viva -Voce	0	0	32	16	50	50
Total Credits:		**0**	**0**	**32**	**16**	**50**	**50**

(L: Lecture periods, T: Tutorial periods, P: Practical periods)

Total Credits of the Programme: 68

List of Audit Courses

1A02/2A03. English for Research Paper Writing
1A02/2A03. Disaster Management
1A02/2A03.Sanskrit for Technical Knowledge
1A02/2A03. Value Education
1A02/2A03. Constitution of India
1A02/2A03. Pedagogy Studies
1A02/2A03. Stress Management by Yoga
1A02/2A03. Personality Development through Life Enlightenment Skills

1NTPC01 SYNTHESIS AND PROPERTIES OF NANOSTRUCTURES

Objective: To cover the whole spectrum of nanomaterials ranging from overview of various synthesis and properties of nanostructures.

Course Outcomes:

1. Beginners will be able to acquaintance themselves with fundamentals of nanostructures.
2. To know the importance of top-down approach synthesis method and their optimization.
3. Students can be able to acquire knowledge on bottom-up synthesis route and may optimize the properties and implement new results.
4. To understand and address various influencing the optical, Morphology and Structural properties of nanomaterials.
5. To provide sound understanding of various concepts involving thermal, magnetic, and mechanical properties of nanomaterials.

Pre-requisite:

1. Familiarization on Crystal Systems.
2. Basics physics & chemistry of atoms and molecules.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	2	2
CO2	3	3	3	3	3
CO3	3	3	3	3	2
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT-I: INTRODUCTION TO NANOMATERIALS : History of nanomaterials, Classification of Nanomaterials, Scientific Revolutions, Nanotechnology and Nanomachines, The Periodic Table, Atomic Structure, Crystal structure, Molecules and Phases, Energy, Molecular and Atomic size, Surfaces and Dimensional Space, Top down and Bottom-up approach.

UNIT-II: TOP-DOWN APPROACHES/PHYSICAL METHODS: Ball Milling, Electrospinning, Lithographic techniques, Electrospinning, Mechanical milling, Etching, Sputtering, Laser Ablation, Molecular beam epitaxy, CVD, Arc discharge, Flame synthesis.

UNIT-III: BOTTOM UP APPROACHES/CHEMICAL METHODS: Sono-chemical routes, Nanocrystals by chemical reduction, photochemical synthesis, electrochemical method, co-precipitation method, Nanocrystals of semiconductors and other materials by arrested precipitation, emulsion synthesis, microwave assisted synthesis, Template based synthesis of nanomaterials, spray pyrolysis and solvated metal atom dispersion, Polymer based synthesis techniques, solvothermal and hydrothermal routes, solution combustion synthesis. Sol-Gel, Electrodeposition, Reverse micelle, Self-assembly techniques, Biological methods – use of bacteria, fungi, for nano-particle synthesis-magnetostatic bacteria for natural synthesis of magnetic nanoparticle, role of plants in nanoparticlesynthesis.

UNIT-IV: STRUCTURAL AND OPTICAL PROPERTIES: Crystallinity, amorphous and phase of nanomaterial, Elemental composition, depth profiling studies, Photonic crystals, optical properties of semiconductors, band edge energy, band gap, Core-shell nanomaterials, Quantum dots etc., for size influences of optical properties, optical transitions, absorptions, Interband transitions, quantum confinements, Fluorescence/luminescence, photoluminescence/fluorescence, optically excited emission, electroluminescence, Laser emission of quantum dot, Photo fragmentation and columbic explosion, luminescent quantum dots for biological labeling.

UNIT–V: THERMAL, MECHANICAL AND MAGNETIC PROPERTIES: Thermal conductivity measurements for nanowires, nanotubes, and thin films. Mechanical Properties of nanomaterials: Types of indentation: Oliver & Pharr, Vickers hardness, Nano Indentation by AFM, Young's modulus, Contact angle, Scratch implant measurements, Magnetic properties: Introduction of magnetic materials, basics of ferromagnetism – ferro magnetic resonance and relaxation, magnetic properties of bulk nanostructures, magnetic clusters, dynamics of nanomagnets, nanopore containment of magnetic particles, nano carbon ferromagnets, ferrofluids, electron transport in magnetic multilayers.

Text & Reference books:

1. Introduction to Nano Technology by Charles. P. Poole Jr& Frank J. Owens. Wiley India Pvt.Ltd.
2. Nanoindentation by Anthony C Fisher-Cripps springer.
3. Encyclopedia of Nano Technology by M. Balakrishna Rao and K. Krishna Reddy, Vol I to X Campus books.
4. Thermal nano systems and Nanomaterials Sebastian Voltz.
5. Handbook of Nano structured materials Vol I & V.
6. Encyclopedia of Nano Technology by H.S. Nalwa.
7. Handbook of Nanotechnology by Bharat Bhushan springer.
8. Nanostructured materials: Processing, Properties and Potential Applications, edited by C.C. Koch, Noyes Publications (2002).
9. Introduction to Nanoscience, S.M. Lindsay, 2009.
10. Inorganic Materials Synthesis and Fabrication by J.N. Lalena, D.A. Cleary, E.E. Carpenter, N.F. Dean, John Wiley & Sons Inc.
11. Introduction to Nano Technology by Charles P. Poole Jr and Frank J. Owens. Wiley India Pvt Ltd.
12. The Chemistry of nanomaterials: Synthesis, Properties and Applications, Vol-I by C.N.R. Rao, A. Muller and A.K. Cheetham.
13. A textbook of Nanoscience and Nanotechnology, Pradeep.T —I, Tata McGraw – Hill education private ltd, 2012.
14. Nano: The Essentials, Pradeep, T, McGraw Hill Publishers, Mumbai, 2007.
15. Kittel. C, —Introduction to Solid State Physics", Wiley India Pvt. Ltd.,2007.

Reference books:

1. Encyclopedia of Nanotechnology by M. Balakrishna Rao and K. Krishna Reddy, Vol I to X, Campus books.
2. Encyclopedia of Nanotechnology by H.S. Nalwa.

Journal references:

1. K K Nanda, Pramana J. Phys., Vol. 72, No. 4, April 2009.
2. V P Skripov, V P Koverda and V N Skokov, Phys. Status Solid A66, 109 (1981).
3. R Goswami and K Chattopadhyay, Act Mater. 52, 5503 (2004).
4. V. Germain et al. J. Phys. Chem. B, Vol. 107, No. 34, 2003.
5. Pignataro, B., Tomorrow's Chemistry Today–Concepts in Nano science, Organic Materials, and Environmental Chemistry, Wiley-VCH, Royal chemical society, 2008.
6. Howard, H., Into the Nano Era: Moore's Law Beyond Planar Silicon CMOS (Vol. 106), Springer Seriesin Materials Science, Springer-Verlag Berlin, 2004.
7. Nanoparticles: Properties, applications and toxicities, Arabian Journal of Chemistry, Volume 12, Issue 7, November 2019, Pages 908-931.

1NTPC02 MATERIALS CHARACTERIZATION TECHNIQUES

Objective:

The intended course covers the whole spectrum of characterization of Nanophase materials.

Course Outcomes:

1. To demonstrate and understand various spectroscopic techniques.
2. To distinguish various compositional and structural characterization techniques.
3. To understand the processing and advanced microscope techniques.
4. To obtain knowledge on electrical and magnetic characterization techniques.
5. To obtain knowledge on characterization techniques involved in Thermal and Mechanical.

Pre-requisite:

1. Basic Instrumentation.
2. Mechanics of solids, Metallurgy, and materials science.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	2	2	2	2	2

UNIT-I: SPECTROSCOPIC TECHNIQUES: UV- Visible Spectroscopy, Photo-luminescence Spectroscopy, Mossbauer spectroscopy, Fourier Transform infrared (FTIR) spectroscopy, Raman spectroscopy techniques: Micro-Raman and Laser Raman, SERS (surface enhanced Raman spectroscopy).

UNIT-II:COMPOSITIONAL AND STRUCTURAL CHARACTERIZATION TECHNIQUES: X-ray Photoelectron Spectroscopy (XPS), Energy Dispersive X-ray analysis (EDAX), Principles and applications of X-ray diffraction; electron diffraction, Electron probe microanalysis (EPMA), Ion beam techniques: SIMS & RBS, BET, PSA and Zeta sizer.

UNIT-III:ADVANCED MICROSCOPY TECHNIQUES: High resolution microscopy; Scanning electron microscopy (SEM), FESEM, Transmission electron microscopy (TEM), HRTEM, Atomic force microscopy (AFM), scanning tunneling microscopy (STM).

UNIT-IV:ELECTRICAL AND MAGNETIC CHARACTERIZATION TECHNIQUES: Measurement of resistivity by Four Point Probe method, Hall measurement, Electron beam induced current measurement (EBIC), Vibrating Sample Magnetometer, SQUID magnetometer, Impedance analyzer, Cyclic Voltammetry.

UNIT-V:THERMAL AND MECHANICAL CHARACTERIZATION TECHNIQUES: Thermal-analysis: TGA, DTA, DSC, DMA, Nano Indentation technique, Micro tensile testing, Micro UTM, Hardness, Impact/ Toughness.

Textbooks:

1. Nano: The Essentials -Understanding Nano Science and Nanotechnology by T. Pradeep, Tata McGraw Hill.
2. Introduction to Nano Technology by Charles. P. Poole Jr and Frank J. Owens, Wiley India Pvt Ltd.
3. A practical approach to X-Ray diffraction analysis by C. Suryanarayana.
4. Electron Microscopy and analysis by P.J. Goodhew and F.J. Humpreys.
5. Characterization of nanostructured materials by Z.L. Wang.
6. Modern Raman Spectroscopy: A practical approach by E. Smith and G. Dent.
7. Principles of Instrumental analysis by D.A. Skoog, F.J. Hollen and T.A. Niemann.
8. Atomic and Molecular Spectroscopy: Basic Aspects and Applications by S. Svanberg.

Reference Books:

1. Nanotechnology: Principles and Practices – Sulabha K. Kulkarni – Capital Publishing Company.
2. Specimen preparation for Transmission Electron microscopy by John &Bravmno et al, published by MRS.
3. Photoelectron spectroscopy by JHD Eland, Butterworth & Co. publishers, 2nd education.
4. Encyclopedia of Nanotechnology by H.S. Nalwa.

1NTPE03 STRUCTURE, BONDING AND QUANTUM MECHANICS

Objective:

The course is intended to cover, basics concepts of crystallography, quantum mechanics, matter and energy relations, de-Broglie hypothesis, wave function analogies, Schrodinger equation, quantum dot, wires, and wells etc.

Course Outcomes:

1. Student can able to theorize the importance of crystal structure for property evaluation.
2. Student can assess different types of chemical bonding in materials.
3. To evaluate nanostructured in quantum mechanical approaches.
4. Students can able to distinguish between classical electromagnetic theory and quantum mechanics.
5. To predict the free electron gas theory of metals and in Hydrogen atom.

Pre-requisite:

1. Basics physics and Quantum mechanics
2. Basic material science

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	1	1	1	1	1

UNIT-I: CRYSTAL STRUCTURE: Crystalline and amorphous solids- Crystal lattice and crystal structure-Translational symmetry-space lattice-unit cell and primitive cell-symmetry elements in crystal-the seven crystal systems-Miller indices-Miller-Bravais Indices-Indices of a lattice direction. Reciprocal lattice and crystal imperfections: Bragg law- Reciprocal lattice – Properties of Reciprocal lattice- Reciprocal lattice of simple cube- Reciprocal lattice of bcc- Reciprocal lattice of fcc- diffraction conditions-Brillouin zones. Importance of lattice imperfections- types of imperfection-Point defects-dislocations.

UNIT II: BONDS: Chemical bonding, Valance shell, Types of bonds and its characteristics, Sigma bond, Pi bond, Ionic bond, Covalent bond, Coordinative covalent bond, Polar bond, Hydrogen bond, Modern theories of chemical bonding, Valance bond theory, Molecular orbital theory.

UNIT-III: QUANTUM MECHANICS INTRODUCTION: Why quantum mechanics - matter waves-length scales - De-Broglie hypothesis – wave particle duality- Heisenberg's uncertainty principle-Schrodinger wave equation – General postulates of Quantum mechanics- particle in one dimensional box, Bohr's correspondence principle.

UNIT-IV: QUANTUM MECHANICS OF ELECTRONICS: Electron as particle and electron as wave-Time independent Schrodinger equation and boundary condition on the wave function-Analogies between quantum mechanics and classical electromagnetic theory-Probabilistic current density-multiple particle systems.

UNIT-V: FREE AND CONFINED ELECTRONS: Free electrons-the free electron gas theory of metals-electrons confined to abounded region of space and quantum numbers-electrons confined to atom-the hydrogen atom and the periodic table-quantum dots-wires-wells, Fermi level and Fermi function.

Textbooks:

1. An introduction to solid states electronic devices by Ajay Kumar Saxena Macmillan India Ltd {Unit-I,II}.
2. Solid state Physics by Kittle {Unit-I, II}.
3. P.M. Mathews and K. Venkatesan, "A textbook of Quantum Mechanics", Tata McGraw Hill Publishing Company Ltd {Unit-III}.
4. Quantum Mechanics – Schiff {Unit-III}.
5. Quantum Mechanics by B.K. Agarwal and Hari Prakash, PHI {Unit-III}.
6. Fundamentals of nanoelectronics by George W. Hanson Pearson education {Unit-IV, V}.

Reference Books:

1. Introduction to Nanotechnology by Charles P. PooleJr& Frank J. Owens; Wiley India Pvt. Ltd.
2. The Feynman lectures on Physics; Vol I to III.
3. Quantum mechanics by Brandsen&Joachem.
4. J.J. Sakurai, "Modern Quantum Mechanics McGraw Hill, Addison Wesley Longman Inc., USA, 1999.
5. Nano Technology and Nano Electronics – Materials, devices and measurement Techniques by WR Fahrner – Springer.

1NTPE03 PHYSICS AND CHEMISTRY OF MATERIALS

Objective:

The course is intended to cover, physical properties, chemical aspects, and nanosytems.

Course Outcomes:

1. To obtain knowledge on physical properties of materials.
2. Students can able to acquire knowledge on chemistry involved in solid surfaces.
3. To know the importance of chemistry aspects within the material.
4. To understand the mechanism within nanostructures.
5. To demonstrate and understand various growth factors in nanosystems.

Pre-requisite:

1. Basics transport phenomenon's
2. Basic chemistry

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT-I: PHYSICAL PROPERTIES: Melting point and phase transition processes- quantum-size-effect (QSE). Size-induced metal-insulator-transition (SIMIT)- nano-scale magnets, transparent magnetic materials, and ultrahigh-density magnetic recording materials-chemical physics of atomic and molecular clusters.

UNIT-II: PHYSICAL CHEMISTRY OF SOLID SURFACES: Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization- surface charge density-electric potential at the proximity of solid surface-Van der Waals attraction potential.

UNIT-III: CHEMISTRY ASPECTS: Photochemistry; Photoconductivity; Electrochemistry of Nanomaterials-Diffusion in Nanomaterials; Nanoscale Heat Transfer; Catalysis by Gold Nanoparticles; Transport in Semiconductor Nanostructures; Transition Metal Atoms on Nanocarbon Surfaces; Nano deposition of Soft Materials; Nano catalysis.

UNIT-IV: NANOSTRUCTURES: Electronic Structure of Nanoparticles- Kinetics in Nanostructured Materials- Zero dimensional, one-dimensional, and two-dimensional nanostructures- clusters of metals and semiconductors, nanowires, nanostructured beams, and nanocomposites-artificial atomic clusters-Size dependent properties-size dependent absorption spectra-phonons in nanostructures.

UNIT-V: NANOSYSTEMS: Nanoparticles through homogeneous nucleation-Growth controlled by diffusion-growth controlled by surface process-influences of reduction reagents-solid state phase segregation-kinetically confined synthesis of nanoparticles-template based synthesis.

References:

1. Ragone. D. V "Thermodynamics of Materials", John Wiley & Sons, 1994.
2. David. R, Gaskell, "Introduction to the Thermodynamics of Materials", Taylor & Francis, 2002.
3. Michael Rieth and Wolfram Schommers, "Handbook of Theoretical and Computational Nanotechnology", American Scientific Publishers, 2005.
4. Lupis. C. H. P, "Chemical Thermodynamics of Materials", Prentice Hall,2000.
5. Christian. J.W, "Theory of Phase Transformations in Metals and Alloys", Pergamon Press, 2001.
6. Günter Radons, BennoRumpf and Heinz Georg Schuster, "Nonlinear Dynamics of Nanosystems", Wiley

INTPE03 PHOTONICS (QUANTUM CONFINED MATERIALS)

Objective:

The course is intended to cover, physical properties, chemical aspects, and nanosytems.

Course Outcomes:

1. Students can be able to acquire knowledge on luminescence materials.
2. To understand and address the importance of plasmonic properties.
3. To obtain knowledge on new approaches in nanophotonics.
4. To provide sound understanding of various concepts of Biophotonics.
5. To visualize the concept of photonic crystals.

Pre-requisite:

1. Basics Electronics
2. Basic chemistry
3. Basic Biology

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT-I: INTRODUCTION: Quantum dots – optical transitions – absorption-inter-band transitions-quantum confinement Intraband transitions-fluorescence/luminescence–photoluminescence /fluorescence optically excited emission – electroluminescence emission.

UNIT-II: PLASMONICS: Internal reflection and evanescent waves- plasmons and surface plasmon resonance (SPR)- Attenuated total reflection- Grating SPR coupling- Optical waveguide SPR coupling- SPR dependencies and materials- plasmonics and nanoparticles.

UNIT-III: NEW APPROACHES IN NANOPHOTONICS: Near-Field Optics- Aperture near-field optics- Apertureless near-field optics- Near-field scanning optical microscopy (NSOM or SNOM)- SNOM based detection of plasmonic energy transport- SNOM based visualization of waveguide structures- SNOM in nanolithography- SNOM based optical data storage and recovery.

UNIT-IV: BIOPHOTONICS: Interaction of light with cells- tissues- nonlinear optical processes with intense laser beams- photoinduced effects in biological systems-generation of optical forces-optical trapping and manipulation of single molecules and cells in optical confinement-laser trapping and dissection for biological systems-single molecule biophysics- DNA protein interactions.

UNIT-V: PHOTONIC CRYSTALS: Important features of photonic crystals- Presence of photonic bandgap- Anomalous Group Velocity Dispersion- Microcavity-Effects in Photonic Crystals- Fabrication of photonic crystals- Dielectric mirrors and interference filters- Photonic Crystal Laser- PC based LEDs- Photonic crystal fibers (PCFs)- Photonic crystal sensing.

References:

1. H. Masuhara, S. Kawata and F. Tokunaga, NanoBiophotonics, Elsevier Science, 2007.
2. V.M. Shalaev and S. Kawata, Nanophotonics with Surface Plasmons (Advances in Nano-Optics and Nano-Photonics), 2007.
3. B.E.A. Saleh and A.C. Teich, Fundamentals of Photonics, John-Wiley& Sons, New York, 1993.
4. M. Ohtsu, K. Kobayashi, T. Kawazoe, and T. Yatsui, Principles of Nanophotonics (Optics and Optoelectronics), University of Tokyo, Japan, 2003.
5. P.N. Prasad, Introduction to Biophotonics, John Wiley & Sons, 2003.
6. J.D. Joannopoulos, R.D. Meade and J.N. Winn, Photonic Crystals, Princeton University Press, Princeton, 1995.

1NTPE03 STATISTICAL THERMODYNAMICS FOR NANOSYSTEMS

Objective:

To introduce to the students the basic principles of statistical thermodynamic principles for nanosystems and to lay emphasis on the fundamentals.

Course Outcomes:

1. To obtain knowledge on thermodynamics systems.
2. Students can be able to acquire knowledge on Nanothermodynamics.
3. To understand the importance of Nonequilibrium thermodynamics.
4. To demonstrate and understand concepts of Nonequilibrium systems.
5. To provide sound understanding of thermodynamics of biological systems.

Pre-requisite:

1. Basics Thermodynamics.
2. Basic Mathematics

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: THERMODYNAMICS OF SMALL SYSTEMS: Non-intensivity and Nonextensivity of Nanosystems -The Gibbs Equation for Nanosystems-Statistical Mechanics and Thermodynamic Property Predictions – Standard polymorphs-formalisms of controlled nucleation and growth of nanocystallites from a vitreous state-thermodynamics of polymorphic transformations in non-porous and nanoporous solids.

UNIT II: NANOTHERMODYNAMICS: Different Approaches to Nanothermodynamics-surface thermodynamics-Phase transitions in nanoparticles-quasi chemical description of solid nanoparticles-size dependent interface energy-thermodynamics of confined fluids in nanopores-structural properties of nanoclusters-Hill's approach to Nanothermodynamics-Phase transition in Nanosystems-symmetry of fullerenes-PI index of some carbon nanotubes.

UNIT III: NONEQUILIBRIUM THERMODYNAMICS: Thermostated Dynamical Systems - The Transient Fluctuation Theorem Thermodynamic Interpretation of the Dissipation Function - The Dissipation Theorem-Nonequilibrium Work Relations- Nonequilibrium Work Relations for Thermal Processes – Corollaries of the Fluctuation Theorem and Nonequilibrium Work Relations -Generalized Fluctuation Theorem - Integrated Fluctuation Theorem -Second Law Inequality - Nonequilibrium Partition Identity - The Steady State Fluctuation Theorem- Minimum Average Work Principle.

UNIT IV: NONEQUILIBRIUM NANOSYSTEMS: Basics-Nanosystems Driven by Time-Dependent Forces-Jarzynski's Nonequilibrium Work Theorem- Mechanical Nanosystems- Friction in Double-Walled Carbon Nanotubes-Electromagnetic Heating of Microplasmas-Mechanochemical Nanosystems-F1-ATPase Motor-Continuous state description-Discrete state description- Chemical Nanosystems- Chemical Transistor- Chemical Clocks in Field Emission Microscopy-DNA replication.

UNIT V: THERMODYNAMICS OF BIOLOGICAL SYSTEMS: Crystal-melt interfacial energies and solubilities for nanosized systems- Via the Ostwald-Freundlich equation, the size-selective growth process of nanoparticles-Bulk membrane partition- Nanothermodynamics of a Single Molecule- The Concept of Pseudo equilibrium- Cellular and Subcellular Systems

References:

1. Ragone. D. V "Thermodynamics of Materials", John Wiley & Sons, 1994.
2. David. R, Gaskell, "Introduction to the Thermodynamics of Materials", Taylor &Francis, 2002.
3. Michael Rieth and Wolfram Schommers, "Handbook of Theoretical and Computational Nanotechnology", American Scientific Publishers, 2005.
4. Lupis. C. H. P, "Chemical Thermodynamics of Materials", Prentice Hall, 2000.
5. Christian. J. W, "Theory of Phase Transformations in Metals and Alloys", Pergamon Press, 2001.
6. Günter Radons, BennoRumpf and Heinz Georg Schuster, "Nonlinear Dynamics of Nanosystems", Wiley publishers, 2010.

INTPE03 GREEN NANOTECHNOLOGY

Objective: To motivate students to gain knowledge in the field of green manufacturing technology.

Course Outcomes:

1. To make the students familiar with the field of traditional manufacturing to green manufacturing.
2. To familiarize with various processing of sustainable green manufacturing.
3. 3.To develop knowledge on alternate energy systems.
4. 4.To familiarize with different types of waste management.
5. To develop the knowledge about the basic concepts of Industrial ecology.

Pre-requisite:

1. Basics Biology.
2. Basic Chemistry.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: GREEN NANOSYNTHESIS: Green Nano synthesis: Green Synthetic Methods for Functionalized Metal Nanoparticles, Green Preparations of Semiconductor, and Inorganic Oxide Nanoparticles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods.

UNIT II: NANOTECHNOLOGY IN REMEDIATION: Nano remediation: Identification and characterization of Hazardous waste, Nano Pollution, Air- Water - Soil Contaminants, Identification and Characterization of Organic and inorganics, Environmental cleanup technologies. Nanomaterials Remediation: Nano Membranes, Nano Meshes, Nano Fibers, Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Nano-Sensors, Detrimental effects and Toxicology of nanomaterials, Compare conventional and green synthesis techniques.

UNIT III: NANOMATERIALS FOR ALTERNATIVE ENERGY: Nanomaterials for Fuel Cells and Hydrogen Generation and storage, Nanostructures for efficient solar hydrogen production, Nanomaterials for Solar Thermal Energy and Photovoltaic. Semiconductor Nanocrystals and Quantum Dots for Solar Energy Applications Nanoparticles for Conducting Heat Transfer.

UNIT IV - NANOMATERIALS FOR "GREEN" SYSTEMS: Green materials, including biomaterials, biopolymers, bioplastics, and composites Nanotech Materials for Truly Sustainable Construction: Windows, Skylights, and Lighting. Paints, Roofs, Walls, and Cooling. Multifunctional Gas Sensors, Biomimetic Sensors, Optical Interference Sensors Thermo-, light-, and stimulus- responsive smart materials Nanomaterials.

UNIT V - GREEN PLASTICS MANUFACTURING: Introduction to commercial plastics and elastomers – Natural Rubber (NR), modified NR and blends-Polyesters from microbial and plant bio factories (Polylactic acid and poly hyroxyalkanoates)- Plastics from vegetable oils -Cellulose and starch-based materials -Natural fillers, fibers, reinforcements, and clay nanocomposites - Biodegradability, life cycle assessment and economics of using natural materials.

References:

1. David. T, Allen, and David R. Shonnard, —Green engineeringl Prentice Hall NJ, 2002.
2. David Dornfeld, —Green manufacturing fundamental and application"Prentice hall, 2002.
3. Sammy Shinga. G —Green electronics design and manufacturing" Princepublications, 2008.
4. James Clark, —Green chemistry" Blackwell publishing, 2008.
5. Paulo Davim, —Sustainable Manufacturing" Wiley publications, 2010.
6. Frank Kreith, George Tchobanoglous, —Solid waste management" McGraw Hill, 2002.
7. Stevens. E. S —Green plastics" Princeton university press, 2002.
8. Robert Ayres. U —A Handbook of Industrial Ecology" Edward elgar publishing, 2002.

1NTPE04 NANO-BIOMEDICAL APPLIATIONS

Objective:

The course is intended to cover biomedical applications of nanotechnology.

Course Outcomes:

1. To familiarize students with biological systems, materials and building blocks.
2. To understand the concepts of Biological Nanostructures.
3. To study various Nanopharmocolgy and Drug targeting system using nanotechnology.
4. To prioritize the role of nano structured materials in diagnosis.
5. To familiarize about Biomedical applications.

Pre-requisite:

1. Basics of organic chemistry.
2. Basics of Biology.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT–I: FUNDAMENTALS OF BIOTECHNOLOGY: Sizes of building blocks and Nanostructures, nucleic acids, genetic code and protein synthesis, Enzymes, DNA Nanotechnology, protein nanoparticles and polypeptide nanowires, Protein &Glyco Nanotechnology, Lipid nanotechnology: Lipid based carrier systems (liposomes, solid-lipid nanoparticles), applications.

UNIT-II: BIOLOGICAL NANOSTRUCTURES: Bio-mimetics with examples, Bio mineralization, Biocompatible Bio sensors, Examples of proteins, micelles, vesicles, bilayers, and Multilayer films, application of bio- nanotechnology: bio nano machines.

UNIT-III: CELLULAR UPTAKE OF NANOMATERIALS: Cellular uptake of nanomaterials: Phagocytosis, Pinocytosis, Nanoparticle properties influencing their uptake, Invitro methods to study antibacterial and anticancer properties of nanomaterials, Nanopharmocolgy, Nanopharmocolgy target, Biodegradable targeted nano drug delivery system, Drug targeting organs, Brains, and eyes.

UNIT-IV: NANOMATERIALS FOR CANCER DIAGNOSIS: Carbon Nanomaterials in biomedical applications, nanoscale polymer fabrication for biomedical application, biosensors, nanotechnology in cancer drug therapy: A biocomputational approach, Nanotoxicology.

UNIT-V: NANOTECHNOLOGY IN ORGAN PRINTING: Organ Printing, types of organ printing, 3D Bio Printing approaches, Nanotechnology for organ printing. Nanotechnology in Tissues Engineering, Nano Artificial Cells: Artificial RBC, applications of artificial cells, synthetic cells and its applications, Nanotechnology in Point of Care Diagnostics: point-of-care tests, paper-based diagnosis, Nanotechnology for point-of-care testing.

Textbooks:

1. Bio Nano Technology by Good Sell, Wiley Liss
2. Nanotechnology by John F. Mongillo
3. Introduction to Nanotechnology by Charles. P. PooleJr and Frank J. Owens, Wiley India Pvt Ltd.
4. Nano Technology, A gentle introduction to the next big idea by Mark Ranter and Daniel Ranter, Pearson education
5. Nanotechnology – science, innovation and opportunity by Lynn E Foster, Prentice Hall– Pearson education.

Reference books:

1. Encyclopedia of Nanotechnology by H.S. Nalwa
2. Encyclopedia of Nanotechnology by M. Balakrishna Rao and K. Krishna Reddy (Vol I to X).

1NTPE04 NANO BIO-TECHNOLOGY

Objective:

The course is intended to cover Biomedical Application and Drug Delivery, Cell Behavior toward Nanotopographic.

Course Outcomes:

1. Students can able to develop deep understanding of Biomedical Application.
2. Student can able to compile all the Drug Delivery Systems.
3. To know the importance of Cell Behavior Toward Nanostructured Surfaces.
4. To prioritize the role of Orthopedic Interface.
5. To gain the improvements in Tissue Engineering/Regenerative Medicine.

Pre-requisite:

1. Basics of Biomedical Application
2. Basics of Biology

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	2	2
CO5	3	3	3	2	2

UNIT–I: MICRO/NANOMACHINING AND FABRICATION OF MATERIALS FOR BIOMEDICAL APPLICATIONS: Introduction, Overview of Ion Implantation Process, Micro/Nanomachining of Soft Polymeric Biomaterials, Micro/Nanomachining of Hard Metallic Biomaterials, Novel Biocompatible Photoresists, Three-Dimensional Lithography.

UNIT–II: NANOTECHNOLOGY AND DRUG DELIVERY: Introduction, Advantages of Nanostructured Delivery Systems, Activation and Targeting of Nanotechnology-Based Drug Delivery Systems (Externally and Internally), Drug Targeting through Targeting Molecules, Multifunctional Nanoparticle Systems, Exploiting Inherent Material Properties.

UNIT–III: CELL BEHAVIOR TOWARD NANOSTRUCTURED SURFACES: Introduction, Nontopographic Surfaces: Fabrication Techniques, Cell Behavior Toward Nontopographic Surfaces Created by: Electron Beam Lithography, Photolithography, Composed of Aligned Nanofibers by Electrospinning, Nanoimprinting, Self-Assembly, Phase Separation, Colloidal Lithography, Composed of Random Nanofibers, Electrospinning, Chemical Etching, Incorporating Carbon Nanotubes/Nanofibers, Polymer Demixing.

UNIT–IV: MULTISCALE COCULTURE MODELS FOR ORTHOPEDIC INTERFACE TISSUE ENGINEERING: Introduction, Cellular Interactions and the Soft Tissue-to-Bone Interface, Types of Coculture Models, Coculture Models for Orthopedic Interface Tissue Engineering, Macro- and Microscale Coculture, Two-Dimensional (2D) and Three-Dimensional (3D) Cocultures, Mechanism of Cellular Interactions During Coculture.

UNIT–V: NANOSTRUCTURES FOR TISSUE ENGINEERING/REGENERATIVE MEDICINE: Introduction, Nanofibrous Scaffolds, Surface Patterned Scaffolds, Relevance of Nanostructured Scaffolds in Regenerative Medicine, Role of Nanostructured Scaffolds in Tissue Engineering.

Textbooks:

1. Bio-Medical nanostructures edited by Kenneth Gonsalves, Craig R Halberstadt, Wiley-Interscience A John Wiley & Sons, Inc., Publication.
2. Introduction to Nanotechnology by Charles. P. PooleJr and Frank J. Owens, Wiley India Pvt Ltd.
3. Nano Technology, A gentle introduction to the next big idea by Mark Ranter and Daniel Ranter, Pearson education.

Reference books:

1. Encyclopedia of Nanotechnology by H.S. Nalwa
2. Encyclopedia of Nanotechnology by M. BalakrishnaRao and K. Krishna Reddy (Vol I to X).

1NTPE04 BIONANOSTRUCTURES

Objective:

The course is intended to cover Nanomaterials involved in Biotechnology aspects.

Course Outcomes:

1. Students can able to develop deep understanding of bio nanotechnology, Nanomotors and proteins.
2. To familiarize with various applications of Biosensors.
3. To understand the importance of Biomimicry.
4. To demonstrate and understand applications of nanomaterials in cancer diagnosis.
5. Students can able to acquire knowledge on Nano Artificial Cells

Pre-requisite:

1. Basics of Biomedical Application
2. Basics of Biology

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	2	2
CO4	3	3	3	2	2
CO5	3	3	3	2	2

UNIT–I: INTRODUCTION TO BIONANOTECHNOLOGY: Multi-DNA Nanomotors, Single DNA Nanomotors, Proteins—Collagens and Elastins and polypeptide nanowires, Glycoproteins, Lipid based carrier systems, applications.

UNIT-II: CLINICAL APPLICATIONS OF MICRO- AND NANOSCALE BIOSENSORS: Classes of Biosensors: Method of Biological Signaling, Method of Transduction, Types of In Vitro Diagnostics: Cantilever-Based Biosensors, Cell and Protein Arrays, In Vivo Diagnostics: Quantum Dots, MRI Contrast Agents, Current and Emerging Clinical Applications of Micro- and Nanoscale Biosensors: Glucose Detection In Vivo, Bacterial Urinary Tract Infections, Human Immunodeficiency Virus (HIV) Detection, Cancer Cell Targeting.

UNIT-III: BIOMIMICRY: Introduction, concepts of biomimicry and bioinspiration in chemistry, Biomimicry and nanostructures, Bioinspired self-assembled structures Self assembled liposome-like systems, Bio mineralization, Biocompatible Bio sensors, Examples of proteins, micelles, vesicles, bilayers, and Multilayer films, application of bio- nanotechnology: bio nano machines.

UNIT-IV: NANOMATERIALS FOR CANCER DIAGNOSIS: Cancer and Early Diagnosis, Cancer and Chemotherapy, Nanotools for Early Cancer Detection, Carbon Nanomaterials in biomedical applications, nanoscale polymer fabrication for biomedical application, nanotechnology in cancer drug therapy: A biocomputational approach, Nanotoxicology.

UNIT-V: DRUG DELIVERY: Different types of drug loading –Drug release –Biodegradable polymers – Applications. Nanostructured Materials in medicine- gold and silver nanoparticles in cancer targeting and treatment –Nanoparticles in treatment of breast cancer –Chemotherapy –Active and Passive cancer tissue targeting –Micro fluidics –Chemotherapeutic agents – Immunotherapy –Vaccine immunotherapy –Radiotherapy – Thermotherapy – Photo dynamic therapy –Nano particulate targeting.

Textbooks:

1. Bio Nano Technology by Good Sell, Wiley Liss
2. Nanotechnology by John F. Mongillo
3. Introduction to Nanotechnology by Charles. P. PooleJr and Frank J. Owens, Wiley India PvtLtd.
4. Nano Technology, A gentle introduction to the next big idea by Mark Ratner and Daniel Ratner, Pearson education
5. Nanotechnology – science, innovation and opportunity by Lynn E Foster, Prentice Hall –Pearson education.
6. Bio-Medical nanostructures edited by Kenneth Gonsalves, Craig R Halberstadt, Wiley-Interscience A John Wiley & Sons, Inc., Publication
7. Bioinspiration and biomimicry in chemistry-reverse engineering nature, Gerhard F. Siegers, Wiley - A John Wiley & Sons, Inc., Publication.
8. J. B Park, "Biomaterials Science and Engineering", Plenum Press, New York, 1984.
9. Kewal K. Jain, The Handbook of Nanomedicine, Humana Press, (2008).

Reference books:

1. Encyclopedia of Nanotechnology by H.S. Nalwa
2. Encyclopedia of Nanotechnology by M. BalakrishnaRao and K. KrishnaReddy
3. Natalie P. Praetories and Tarun K. Mandal, Recent Patents on Drug Delivery&Formulation
4. Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed. Pan Stanford Publishing,(2005).

1A01 RESEARCH METHODOLOGY & IPR

Objective: To understand the Research methodology and IPR.

Course Outcomes:

1. Analyze research related information
2. Follow research ethics
3. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
4. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
5. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope, and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II: Effective literature studies approaches, analysis Plagiarism, Research ethics.

UNIT III: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

UNIT IV: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development International Scenario: International cooperation on Intellectual Property. Procedure for Grants of patents, Patenting under PCT.

UNIT V: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT VI: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science& engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step-by-Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

1NTL05 SYNTHESIS OF NANOMATERIALS LAB

Objective: The course is intended to cover basic preparation methods of nanomaterials.

Course Outcomes:

1. Gain knowledge on the synthesis techniques involved in experiments.
2. To construct a practical knowledge on the experiment.
3. The ability to write and present the laboratory reports.
4. To maximize knowledge regarding synthesis and processing of nanomaterials.
5. To acquire knowledge on synthesis parameters.

Pre-requisite:

1. Basic Chemistry.
2. Basic Instrumentation.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

Experiments:

Bottom Up Approaches:

1. Synthesis of ZnO nanoparticles using Urea as fuel by Solution Combustion Method.
2. Synthesis of Core Shell PVP capped Cadmium Sulfide (CdS) nanoparticles Chemical Co-Precipitation Method.
3. Development of silica gel (SiO_2) using Sol-Gel method.
4. Preparation of Silver nanoparticles by using green synthesis from Aloe vera extract.
5. Fabrication of NiO nanomaterials by Microwave method.
6. Synthesis of MgO nanomaterials by Hydrothermal method.
7. Synthesis of Iron Oxide nanomaterials by Chemical Vapour Deposition (CVD) method.
8. Development of Polymer nanofibers by Electrospinning method.
9. Synthesis and characterization of carbon nanomaterial by cracking of gas mixture using tubular furnace.
10. To Improve Hummers method for eco-friendly synthesis of graphene oxide.
11. An ultrasonic method for the synthesis, control, and optimization of CdS/TiO_2 core–shell nanocomposites.
12. Environment-friendly biomimitic synthesis of copper oxide nanoparticles by Yeast/Fungus/Bacteria.
13. Symmetry – Breaking synthesis of Multicomponent Nanostructures.
14. Synthesis of Nanosized Metal Organic frameworks.

Top-down up Approaches:

15. To study the forming characteristics of TiO_2 nanostructure by mechanical alloying using high energy planetary ball mill.
16. Grain Refinement through heat treatment of Ni/Al2O3 Nanocrystals

1NTL06 FABRICATION AND CHARACTERIZATION OF NANOMATERIALS

Objective: To impart the knowledge on application of thin film technology to fabricate and characterization of nanomaterials.

Course Outcomes:

1. Gain knowledge on the fabrication and characterization techniques of nanomaterials.
2. Students can acquire knowledge on equipment handling like XRD, PSA, UV etc.
3. To construct a theoretical knowledge
4. The ability to write and present the laboratory reports.
5. To maximize knowledge regarding fabrication and characterization of nanomaterials.

Pre-requisite:

1. Basic Electronics
2. Basic instrumentation

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

Experiments:

1. Fabrication of thin film by Dip coating.
2. Fabrication of thin film by Spin coating.
3. Fabrication of thin film by Spray Pyrolysis.
4. Fabrication of thin film by Thermal evaporation technique.
5. Determination of average Crystallite size and Macrostrain by using X-Ray diffraction Analysis.
6. To work out the charge, zeta potential and size distribution of colloidal solution of nanoparticles using dynamic light scattering method.
7. Calculation of band gap with error bar values and particle size by using UV-Visible spectroscopy.
8. Study of thermal properties of nanomaterials by using TG/DTA analysis.
9. FTIR spectroscopy method for investigation of nanoparticle nano surface phenomena.
10. Specific BET Surface Area Measurement and and pore size distribution of Nanomaterials.
11. In situ assessment of the contact angles of nanoparticles adsorbed at fluid interfaces by multiple angles of incidence ellipsometry.
12. CV characteristics of nanomaterial using three electrode system.
13. Gas sensor

2NTPC07 NANO SENSORS AND DEVICES

Objective:

The course is intended to cover sensors and different types of sensors with their characteristics and their applications.

Course Outcomes:

1. To develop knowledge about Sensors, Characteristics, design and its applications.
2. To persuade about the Physical Effects of Sensor.
3. To visualize the concept of Mass Sensitivity and Conductive Sensors.
4. To understand the importance of Electro Chemical Sensors and its measurement types.
5. Student can able attain knowledge on Thermometric & Optical sensors.

Pre-requisite:

1. Basics of nano liners optics and electronics.
2. Basic of sensors, physical, chemical, mechanics phenomenon's related to sensors.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	2
CO5	3	3	3	3	2

UNIT I: INTRODUCTION &SENSOR CHARACTERISTICS: Nanotechnology, Sensors, Nanotechnology Enabled Sensors,Sensor Characteristics and Terminology, Static Characteristics, Dynamic Characteristics, Physi caleffects Employed for Signal Transduction, Design and Applications.

UNIT-II: SENSORS& PHYSICAL EFFECTS: Photoelectric Effect, Photo-dielectric Effect, Photo-luminescenceEffect,Electroluminescence Effect, Chemiluminescence Effect, Doppler Effect, Barkhausen Effect, Hall Effect, Nernst/Ettingshausen Effect, Thermoelectric (Seebeck/Peltier and Thomson) Effect, Thermoresistive Effect, Piezo resistive Effect, Piezoelectric Effect, Pyroelectric effect, Magneto-Mechanical Effect (Magnetostriction), Magneto resistive Effect, Faraday-Henry Law.

UNIT-III: MASS-SENSITIVE & CONDUCTIVITY SENSORS: BAW Sensors, SAW Sensors, ConductometricSensors, Resistive and Capacitive Gas Sensors,Gas Sensors Based on PolycrystallineSemicondu ctors, GasSensors Made of Polymers and Gels, Resistive and Capacitive Sensors for Liquids.

UNIT-IV ELECTROCHEMICAL SENSORS: Potentiometric Sensors, Selectivity of Potentiometric Sensors IonSelective Electrodes,The Ion Selective Field Effect Transistor (ISFET), Measurement with Potentiometric Se nsors, Amperometric Sensors Selectivity of Amperometric Sensors, Electrode Design and Examples, Measureme nt with Amperometric Sensors, Sensors Based on Other Electrochemical Methods, Electro-Chemical Biosensors, Classes of Electrochemical Biosensors.

UNIT-V: THERMOMETRIC & OPTICAL SENSORS: Sensors with Thermistors and Pellistors, Pyroelectric Sensors, Sensors Based on Other Thermal Effects, Optical Fibers as a Basis for Optical Sensors, Fiber Sensors without Chemical Receptors (Mediators), Optodes: Fiber sensors with a chemical receptor, Optodes with simple receptor layers, Optodes with complex receptor layers, Pressure Sensors.

Textbooks:

1. Nanotechnology-Enabled Sensors, KouroshKalantar-zadeh, Springer publications (2007).
2. Chemical Sensors-An Introduction for Scientists and Engineers, Peter Grundler, Springer publications (2006).
3. Design and Applications of Nanomaterials for Sensors by Jorge M. Seminario, Jerzy Leszczynski, Springer, Volume-16, 2014.

2NTPC08 INDUSTRIAL TRENDS AND APPLICATIONS OF NANOTECHNOLOGY

Objective: To provide knowledge of various industrial applications of nanotechnology.

Course Outcomes:

1. To elucidate on advantages of nanotechnology-based applications in industries.
2. To provide instances of contemporary industrial applications of nanotechnology.
3. To provide an overview of future technological advancements and increasing role of nanotechnology in Industries.
4. To understand the importance of Nanotechnology in textiles and cosmetics.
5. To visualize the concept of Nanotechnology in Space and Defence.

Pre-requisite:

1. Study of Microelectronics, Sensors, Solar cells, Biological materials.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT–I: NANOTECHNOLOGY IN ELECTRONICS AND ENERGY: Miniaturization- Nano electronic devices and circuits – Semiconductor Memories - Dynamic Radom Access Memory- Nonvolatile Semiconductor Memories- Quantum Dot based Memory Cell- Sensors; physical and chemical- Electronic noses- Actuators- Micro and Nano-Electromechanical systems– Lighting and Displays –Quantum optical devices- Lasers – Batteries – Super capacitors- Fuel cells–role of nanomaterials in fuel cell applications- Photovoltaic cells –Application of nanotechnology in solar cells- Application of power in transportation including space Carbon Nano structures and types of Carbon Nano tubes, growth mechanisms, Mechanical reinforcements, Graphene, Carbon Nano fibers, Carbon clusters, Diamond.

UNIT–II: NANOTECHNOLOGY IN BIOMEDICAL INDUSTRY: Nanoparticles and Micro–organism- Biosensors- Bioreceptors and their properties - Biochips- Integrated Nanosensor networks for detection and response- DNA based biosensors and diagnostics- Natural nanocomposite systems; spider silk, bones, shells - Nanomaterials in bone substitutes and dentistry – Implants and Prosthesis –Tissue Engineering – Neuroscience - Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy - Protein Engineering – Nanosensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications.

UNIT–III: NANOTECHNOLOGY IN AGRICULTURE AND FOOD SECTOR: Nanotechnology in Agriculture -Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges- Product innovation and Process improvement- Consumer benefits- Food processing - Packaging- - Packing materials; physical properties- Improvements of mechanical and barrier properties- Antimicrobial functionality- Active packaging materials- -Information and communication technology- Sensors- RF identification- Food safety- Nanomaterial based Food diagnostics – Contaminant detection – Intelligent packaging- Nanoengineered Food ingredients- Potential risks to Nanofood to consumers.

UNIT IV - NANOTECHNOLOGY IN TEXTILES AND COSMETICS: Nanofiber production – Electrospinning and charge injection method – morphological control- yarns and polymidenanofibers- Carbon Nanotube and Nanofiber Reinforced Polymer Fibers- multifunctional polymer nanocomposites- Improvement of polymer functionality- Nylon-6 nanocomposites from polymerization- Dyeable Polypropylene - nano coatings and surface modifications - Nano-filled polypropylene fibers - UV resistant, antibacterial, self-cleaning, flame retardant textiles – Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear textiles- Cosmetics; Formulation of Gels, Shampoos, Hair-conditioners–Nanomaterials in Sun-screen UV protection – Color cosmetics.

UNIT V - NANOTECHNOLOGY IN DEFENCE AND AEROSPACE: Pathways to Physical protection-Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures- Decontamination- Post exposure and pre exposure protection and decontamination- Nanotechnology enabled bio chemical weapons- Influence operations- Evasion of medical countermeasures- Nanotechnology based satellite communication system- Guidance, Navigation and control- Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical microsensors for space craft and launch support-Micro/Nano pressure and temperature sensors for space missions.

Textbooks and References:

1. Mark. A, Ratner, and Daniel Ratner, "Nanotechnology: A Gentle Introduction to theNext Big Idea", Pearson, 2003.
2. Bharat Bhushan, "Springer Handbook of Nanotechnology", Barnes & Noble 2004.
3. Neelina. H, Malsch (Ed.), "Biomedical Nanotechnology", CRC Press 2005.
4. Udo. H, Brinker, Jean-Luc Mieusset (Eds.), "Molecular Encapsulation: Organic Reactions in Constrained Systems", Wiley Publishers 2010.
5. Jennifer Kuzma and Peter VerHage, "Nanotechnology in agriculture and food production", Woodrow Wilson International Center, 2006.
6. Lynn. J, Frewer, WillehmNorde. R. H, Fischer and Kampers. W. H "Nanotechnology in the Agri- food sector", Wiley-VCH Verlag, 2011.
7. Brown. P. J and Stevens. K "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge, 2007.
8. Mai. Y-W "Polymer Nano composites", Woodhead publishing, 2006.
9. Chang. W.N "Nanofibers fabrication, performance and applications", Nova Science Publishers Inc,2009.
10. Helvajian. H and. Robinson. E.Y "micro and nanotechnology for space systems" the aerospace corporation, Micrograph , 1997.
11. Margaret. E, Kosal, "Nanotechnology for Chemical and Biological Defence, Springer 2009.

2NTPE09 NANO TECHNOLOGY FOR ENERGY SYSTEMS

Objective:

The course covers the various energy forms, alternate and renewable energy system using nanotechnology.

Course Outcomes:

1. Study the basic Energy need and role of Battery materials
2. To grade up knowledge of Super Capacitors, and its applications.
3. Study the role of nano structured material to meet Energy Challenges.
4. Learn about the concept of Hydrogen Storage Technology.
5. Gain knowledge on role of Fuel Cell Technology.

Pre-requisite:

1. Basic Energy Systems
2. Basic Chemistry

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT–I: ENERGY STUDIES: Why clean energy, Different energies: Nuclear energy, Hydro power, Wind energy, Battery: Introduction to Battery materials and batteries: Lithium-Ion based batteries, Sodium-Ion batteries, Redox-Flow batteries.

UNIT–II: SUPER CAPACITORS: Super capacitor characterization, Types of super capacitors, double layer and pseudo capacitance, hybrid super capacitors, super capacitors: Electrochemical double layer and pseudo-capacitors, Hybrid supercapacitors, advantages, and disadvantages of electrochemical double layer, Psudocapacitors and hybrid supercapacitors., Applications of supercapacitors.

UNIT–III: RENEWABLE ENERGY TECHNOLOGY: Energy challenges, nanomaterials and nanostructures in energy harvesting, developments and implementation of nanotechnology based renewable energy technologies, solar cell structures: quantum well and quantum dot solar cells, photo- thermal cells for solar energy harvesting, Thin film solar cells, CIGS solar cells, Die sensitized solar cells, Perovskite solar cells.

UNIT–IV: HYDROGEN STORAGE TECHNOLOGY: Hydrogen production methods, purification, hydrogen storage methods and materials: metal hydrides and metal-organic framework materials, volumetric and gravimetric storage capacities, hydriding and dehydriding kinetics, high enthalpy formations and thermal management during hydriding reaction, multiple catalytic – degradation of sorption properties, automotive applications.

UNIT–V: FUEL CELL TECHNOLOGY: Fuel cell Principles, types of fuel cells (Alkaline Electrolyte, Phosphoric acid, Molten Carbonate, solid oxide and direct methanol and Proton exchange fuel cells), Principle and operation of Proton Exchange Membrane (PEM) fuel cell, Materials and fabrication methods for fuel cell technology, micro fuel cell power sources – Biofuels, Microbial biofuels.

Textbooks & References:

1. Electrochemical supercapacitors for energy storage and delivery by Aiping Yu, Tay. & Franc, 2013.
2. Renewable Energy Resources by J. Twidell and T. Weir, E&FN Spon Ltd.
3. Hydrogen from Renewable Energy Source by D. Infield
4. Fundamentals of Industrial Catalytic Process by C.H. Bartholomew and Robert J. Farraoto, John
5. Fuel storage on Board Hydrogen storage in Carbon Nanostructures by R.A. Shatwell
6. Fuel cell Technology Handbook by Hoogers, CRC Press
7. Electrochemical Supercapacitors, B E Conway, Kluwer Academic/Plenum publishers, NY 1999.

2NTPE09 NANO ELECTRONICS AND NANO PHOTONICS

Objective:

This course is intended to cover basics of electronics, transistor, band structure models, nanocapacitors, coulomb blockade, single electron transistor and nanophotonics.

Course Outcomes:

1. To assess knowledge on Single Electron and few Electron phenomenon.
2. To determine theory behind Scanning Tunneling Microscope by Applications of Tunneling.
3. Study the basics of coulomb blockade in Quantum mechanics.
4. To persuade Single Electron Transistor and Carbon Nano tube transistor.
5. To extend the knowledge on Spintronics and Nano photonics.

Pre-requisite:

1. Basics of nano linear optics
2. Basics of electronics

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	2

UNIT-I: SINGLE-ELECTRON AND FEW-ELECTRON PHENOMENA AND DEVICES: Tunnel junction and applications of tunneling, Tunneling Through a Potential Barrier, Potential Energy Profiles for Material Interfaces, Metal—Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions.

UNIT-II: APPLICATIONS OF TUNNELING: Field Emission, Gate—Oxide Tunneling and Hot Electron Effects in MOSFETs, Theory of Scanning Tunneling Microscope, Double Barrier Tunneling and the Resonant Tunneling Diode.

UNIT-III: COULOMB BLOCKADE: Coulomb Blockade, Coulomb Blockade in a Nanocapacitor, Tunnel Junctions, Tunnel Junction Excited by a Current Source, Coulomb Blockade in a Quantum Dot Circuit.

UNIT-IV: THE SINGLE-ELECTRON TRANSISTOR: The Single-Electron Transistor Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs, Molecular SETs and Molecular Electronics.

UNIT –V: SPINTRONICS: Spintronics -GMR & TMR effects and Foundations of nano-photonics – OLED.

Textbooks:

1. Fundamentals of nano electronics by George W Hanson Pearson publications, India 2008
2. Introduction to photoelectron Spectroscopy (Chemical Analysis Vol. 67) by P.K. Ghosh.
3. Nanophotonics by P.N. Prasad – Springer Education series.

Reference books:

1. Encyclopedia of Nano Technology by M. Balakrishna Rao and K. Krishna Reddy (Vol I to X) Campus books.
2. Spin Electronics by M. Ziese and M.J. Thornton
3. Introduction to Nanoscience by S.M Lindsay, 2009.

2NTPE09 NANO COMPOSITES DESIGN AND SYNTHESIS

Objective: This course intended to cover composites material design and preparation.

Course Outcomes:

1. Student can able to discuss the basic concepts of Nano Composites.
2. Student can able to prioritize the role of Ceramic Metal Composites in Nano Technology.
3. To understand the role of Synthesis Methods for various Nano Composite materials.
4. Learn about the concepts of Indentations and types of Indentations.
5. Correlate the applications of Polymer Nano Composites and Impregnation Techniques.

Pre-requisite:

1. Basics of composites
2. Basic Material Science

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT–I: INTRODUCTION TO NANOCOMPOSITES: Composite material, Mechanical properties of Nanocomposite material: stress - strain relationship, toughness, strength, plasticity.

UNIT–II: CERAMIC-METAL NANOCOMPOSITES: Ceramic based nano porous composite, Metal matrix nanocomposites, Polymer-based nanocomposites Carbon nanotube-based nanocomposites and Natural nanobiocomposites, Biomimetic nanocomposites and biologically inspired nanocomposites.

UNIT–III: SYNTHESIS METHODS FOR VARIOUS NANOCOMPOSITE MATERIALS: mechanical alloying, thermal spray synthesis etc. Nano composites for hard coatings; Multi layered coatings; Thin film nanocomposites; Modeling of nanocomposites.

UNIT–IV: TYPES OF INDENTATION: Oliver & Pharr, Vickers indentation process, Nano-Indentation by AFM Influence ofInterface, Molding, Injection molding, Design Selection Methodology for Composite Structures.

UNIT–V: PROCESSING OF POLYMER NANOCOMPOSITES: Properties of nanocomposites, Infiltration techniques, Stir mixing, Extrusion method, Intercalation and Exfoliation, Solution casting method, impregnation techniques: Hot melt impregnation, solution impregnation, spin coating.

Textbooks:

1. Nanocomposite Science & Technology byP.M. Ajayan, L.S. Schadler and P.V. Braun, Wiley-VCH GmbH Co.
2. Introduction to Nano Technology by Charles. P. PooleJr and Frank J. Owens; Wiley India Pvt Ltd.
3. Nanotechnology, A gentle introduction to the next big idea by Mark Ratner, Daniel RatnerPearson
4. Polyoxometalate Chemistry for Nano- Composite Design
5. Rheology and processing of polymer nanocomposites by Sabu Thomas, JiJi Abraham-Wiley Publications
6. Nano Composites by K. K. Chawla,

Reference books:

1. Encyclopedia of Nanotechnology by H.S. Nalwa
2. Encyclopedia of Nano Technology by M. Balakrishna Rao and K. Krishna Reddy, Vol I to X Campus books.

2NTPE09 NANOTRIBOLOGY

Objective: This course provides the students about the engineering aspects of tribology which one can apply in product development, failure analysis and condition monitoring.

Course Outcomes:

1. To provide sound understanding of various concepts related to tribology.
2. Students can able to acquire knowledge on surface forces and measuring techniques.
3. To know the importance of Lubrication, friction, and fear.
4. To develop knowledge on Scale Effects in Mechanical Properties and Tribology.
5. To get awareness on applications of tribology.

Pre-requisite:

1. Basic physics
2. Basics of Mechanical engineering.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: INTRODUCTION TO TRIBOLOGY: History of tribology, origin, and Significance of micro/nanotribology Tribology in design, methods of solution of tribological problems. Purpose of lubrication, modes of lubrication- hydrodynamic, Hydrostatic Boundary lubrication, hydrodynamic lubrication, Extreme pressure lubrication Lubricants - types and lubricating oils Lubricant properties-effect of temperature and pressure, oxidation stability, thermal conductivity, type of additive Bearings- classification based on mode of lubrication Bearing-Classification based on relative motion between contact surfaces. Comparison of sliding and rolling contact bearing, solving numerical on above topic.

UNIT II: SCALE EFFECTS IN MECHANICAL PROPERTIES AND TRIBOLOGY: Nomenclature, scale effect in mechanical properties, Yield strength, shear strength, Scale effect on surface roughness and contact parameters, Scale effects in friction – adhesion, stiction, two body deformation, Three body deformation, Ratchet mechanism, elastic to plastic regime, Tailoring surfaces: Modifying surface composition and structure(texture) for application in Tribology.

UNIT III: SURFACE FORCES AND MEASURING TECHNIQUES: Methods used to study surface forces- force laws Surface force apparatus (SFA)Force between dry surface, force between surfaces in liquid Adhesion and capillary forces, modes of deformation Description of AFM/FFM and various measurement techniques Surface roughness and friction force, Adhesion Scratching, wear, and machining Surface potential measurements Nanoindentation measurement, boundary lubrication, Tribological properties ofSAMs.

UNIT IV: LUBRICATION, FRICTION AND WEAR: Lubricant States, viscosity of lubricant Fluid film lubrication, Theories of hydrodynamics lubrication, Lubrication design of typical mechanical elements, transformation, Parameter of surface topography, Friction of materials, solid – solid contact, Liquid mediated contact, interfacing temperature of sliding surfaces, Types of wear mechanism, Typical test geometries.

UNIT V: APPLICATIONS OF TRIBOLOGY: Introduction to various tribological phenomenon, Bio-Tribology – Tribology in the human body, artificial organs, Tribology in medical devices, Natural human synovial joints and total joint replacements, Wind turbine Tribology, Biorefining, Coating application - sliding bearings, rolling contact, Bearings, gears, erosion and scratch resistant, Magnetic recording devices, Micro components, MEMS/NEMS.

Textbooks:

1. H.G. Phakatkar and R.R. Ghorpade, "Tribology", Nirali publication, 2009.
2. Bharat Bhushan, "Nanotribology and Nanomechanics", Springer Publication, Second edition,2011.
3. Bharat Bhushan," Principles and Applications to Tribology", Wiley Publication, 2013.
4. C. Mathew Mate, "Tribology on the Small Scale" Oxford University Press, 2008.
5. Nicholas D. Spencer, "Tailoring surfaces", World Scientific IISC Press, 2011.

2NTPE10 SCIENCE AND TECHNOLOGY OF THIN FILMS

Objective:

The course covers the importance of thin film technology and nanofabrication.

Course Outcomes:

1. To develop deep understanding on Vacuum Technology.
2. To compile all the Conditions for formation of thin films.
3. To know the importance of Physical Vapor Deposition techniques.
4. To prioritize the role of Electrical discharges used in Thin Film Deposition.
5. To improve the understanding of deposition using CVD.

Pre-requisite:

1. Basic Electronics
2. Basics of vacuum pump technology

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

UNIT-I: VACUUM TECHNOLOGY: principles of vacuum pumps in range of 10^{-2} torr to 10^{-11}torr, principle of different vacuum pumps: roots pump, rotary, diffusion, turbo molecular pump, cryogenic-pump, ion pump, Ti-sublimation pump, importance of measurement of vacuum, Concept of different gauges: Bayet- Albert gauge, Pirani, Penning and pressure control.

UNIT–II: CONDITIONS FOR THE FORMATION OF THIN FILMS: Environment for thin film deposition, deposition parameters and their effects on film growth, formation of thin films (sticking coefficient, formation of thermodynamically stable cluster – theory of nucleation), Zone model and Thornton model for thin film growth, capillarity theory, microstructure in thin films, adhesion, properties of thin films: Mechanical, electrical, and optical properties of thin films.

UNIT-III: PHYSICAL VAPOR DEPOSITION TECHNIQUES: Thermal evaporation, resistive evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition, Electron beam and Ion beam lithography techniques.

UNIT-IV: ELECTRICAL DISCHARGES USED IN THIN FILM DEPOSITION: Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion beam sputtering, Ion plating, difference between thin films and coating.

UNIT-V: FABRICATION OF THIN FILMS: Electro deposition, molecular beam epitaxy and laser pyrolysis. Chemical vapor deposition techniques: Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, boundaries and flow, Different kinds of CVD techniques: Metallorganic CVD (MOCVD), Plasma Enhanced CVD (PECVD), thermally activated CVD, CVD, Spray pyrolysis, etc.

Textbooks & References:

1. Thin Film Phenomenon by K.L. Chopra, McGraw-Hill.
2. Methods of Experimental Physics (Vol 14) by G.L. Weissler and R.W. Carlson "Vacuum Physics and Technology".
3. A User's Guide to vacuum Technology by J.F. O'Hanlon, John Wiley and Sons.
4. Vacuum Physics and Techniques by T.A. Delchar, Chapman and Hall.
5. Evaporation: Nucleation and Growth Kinetics" by J.P. Hirth and G.M. Pound, Pergamon Press.
6. Handbook of Vacuum Science and Technology by Dorothy M. Hoffman, Bawa Singh, John H. Thomas, III, Academic Press-Elsevier

2NTPE10 LITHOGRAPHIC TECHNIQUES

Objective: The course is intended to cover deep understanding of basics and different types of lithographic techniques useful for Nanofabrication.

Course Outcomes:

1. To discuss about Lithography and Optical Lithography
2. To formulate the role of Electron Lithography
3. To construct the idea of X-ray Lithography
4. To improve our knowledge in Ion Lithography
5. To understand the importance of Lithography based on Surface Instabilities

Pre-requisite:

1. Clean room technology
2. thin films coating techniques.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

UNIT I: INTRODUCTION TO LITHOGRAPHY AND OPTICAL LITHOGRAPHY: Introduction to lithography- Contact, proximity printing and Projection Printing, Resolution Enhancement techniques, overlay-accuracies, Mask-Error enhancement factor (MEEF), Positive and negative photoresists.

UNIT II: ELECTRON LITHOGRAPHY: Electron optics, Raster scan and Vector scan, Electron proximity / Projection Printing, Direct writing, Electron resists, Electron Beam Applications.

UNIT III:X-RAY LITHOGRAPHY: X-ray Proximity and projection printing X-ray masks, X-ray sources, X-ray resists.

UNIT IV: ION LITHOGRAPHY: Focused ion beam – Point sources of Ion, Ion Column, Beam writing, Focused Ion Beam Lithography, Masked Ion Beam Lithography, Ion Projection Lithography.

UNIT V: LITHOGRAPHY BASED ON SURFACE INSTABILITIES: Wetting, De-wetting, Adhesion, Limitations, Resolution and Achievable / line widths of each of the above techniques.

Reference books:

1. K.L. Chopra, "Thin Film Phenomenon", McGraw-Hill, 1968
2. JohnN.Helbert, "Handbook of VLSI Microlithography", Noyes Publication, USA, 2001.
3. James R Sheats and Bruce w. Smith, "Microlithography Science and Technology", Marcel Dekker Inc., New York, 1998.
4. S. Wolf "Silicon processing for the VLSI era", Vol-1 to 4, Lattice Press.
5. J.P. Hirth and G.M. Pound "Evaporation: Nucleation and Growth Kinetics" (Pergamon Press, Oxford, 1963.
6. Handbook of Microscopy for Nanotechnology- Nan Yao &Zhong ling wang Kluwer Academic publishers
7. Nanofabrication. Principles, Capabilities and Limits Zheng Cui Springer publications
8. Scanning Microscopy for Nanotechnology Techniques and Applications edited by Weilie Zhou and Zhong Lin Wang springer publications

Journals references:

1. R.F. Bunshah and C.V. Deshpandey "Evaporation Processes" MRS Bulletin p.33, Dec.1988.
2. W.D. Westwood "Sputter Deposition Processes" MRS Bulletin p.46, Dec.1988.
3. P. Harris "Taking the Lead in Electron-redeposition" Vacuum& Thin Film, Feb.1999,p.26.
4. B. Heinz Sputter Target and Thin Film Defects" Vacuum & Thin Film, October1999,p.22.
5. G.S.Bales et al., "Growth and Erosion of Thin Splid Films", Science, 249, 264 (1990).
6. C.R.M. Grovenor, H.T.G. Hentzell and D.A. Smith, "The Development of GrainStructure during Growth of Metallic Films" ActaMetallurgica 32, 773 (1984).
7. L.A.Stelmack, C.T.Thurman and G.R. Thompson "Review of Ion-assisted Deposition:
8. Research to Production", Nuclear Instruments and Methods in Physics Research B, 37/38,787(1989).

2NTPE10 MEMS/NEMS DESIGN AND APPLICATIONS

Objective: The course is intended to cover deep understanding of micro and nano electromechanical systems their design and various applications as well as micro and nano fabrication techniques.

Course Outcomes:

1. To improve the understanding of MEMS/NEMS.
2. To provide silicon micro fabrication techniques etc.
3. To understand the importance of MEMS Sensors, Design and Processing
4. To bring out scaling and packaging issues of physical system.
5. To provide understanding of MEMS/NEMS applications.

Pre visit Request:

1. Mechano- electronic properties
2. Fabrication techniques.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

UNIT-I: INTRODUCTION TO MEMS: MEMS and NEMS – working principles- MEMS processes & features, various components of MEMS, applications and standards, micromachining, basic process tools- epitaxy, sputtering, chemical vapor deposition and spin on methods, oxidation, evaporation, lithography and etching, advanced process tools, sol gel process, EFAB.

UNIT-II: MATERIALS FOR MEMS AND ENGINEERING ASPECTS: Silicon, Silicon oxide and nitride, Thin metal films, Polymers, Other materials and substrates, polycrystalline materials, mechanics of Microsystems, static bending, mechanical vibrations, thermo mechanics, fracture mechanism, fatigue, stress and strain, young's modulus and modulus of rigidity, scaling laws in miniaturization.

UNIT-III: MEMS SENSORS, DESIGN, AND PROCESSING: Micro sensors (acoustic wave sensors, biomedical sensors, chemical sensors, optical sensors, capacitive sensors, pressure sensors, thermal sensors), micro actuators (thermal, piezoelectric, electrostatic actuators, micrometers, microvalves& pumps, accelerometer, microfluidics and devices), design consideration, process design and mechanical design.

UNIT-IV: MEMS/NEMS SCALING ISSUES AND PACKAGING: Introduction – Scaling of physical systems – Mechanical system scaling, Thermal system scaling, Fluidic system scaling, Electrical system scaling, Packaging- mechanical and microsystem package, design considerations, Process steps, Diepreparation- interconnects, surface and Wafer bonding, wire bonding and scaling, 3D packaging and assembly signal Thermal management, Hermetic packaging, Electrical//Micro fluidic/and optical interconnects, Signal mapping transduction, Microfluidic technology - MEMS and NEMS technology for microfluidic devices.

UNIT-V: MEMS/NEMS APPLICATIONS: Applications in automotive industry – health care – aerospace – industrial product consumer products – lab on chip – molecular machines – data storage devices – micro reactor – telecommunications, Servo systems.

Textbooks:

1. "An introduction to Micro electromechanical systems Engineering" by NadimMalut and Kirt Williams – Second edition – Artech House, Inc, Boston.
2. "Micro electromechanical systems Design". / By James J Allen- CRC Press – Taylor and Francis Group
3. "Mechanics of micro electromechanical systems "by NicolaeLobontiu and Ephrahim Garcia Kluwer. Academic Publishers – Boston.
4. The Physics of Micro/Nano- Fabrication by Ivor Brodie and Julius J.Muray.
5. Nano- and Micromaterials by Kaoru Ohno, Masatoshi Tanaka, Jun Takeda and Yoshijuki Kawazoe.

References Books:

1. "Springer Hand Book of Nano Technology " by BharathBhushan – Springer
2. "Nano and Micro electro Mechanical systems" by Sergey Edward Lysherski – CRC Press.

2NTL11 NANOSTRUCTURED MATERIAL APPLICATION LAB

Objective: The course is intended to cover understanding of nanomaterial synthesis, fabrication and characterization technique.

Course Outcomes:

1. To gain overall knowledge on synthesis, characterization, and application of nanomaterials.
2. Students can acquire knowledge on equipment handling like Cyclic voltammetry, Anti-bacterial applications, gas sensor etc.
3. To construct a theoretical knowledge on the experiment.
4. The ability to write and present the laboratory reports.
5. To maximize knowledge regarding synthesis, characterization, and applications of nanomaterials.

Pre-requisite: Synthesis, Characterization Techniques, and applications.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

Experiments:

1. Nanomaterials: Synthesis, Characterization and Humidity Sensing Application.
2. Nanoclusters for Gas Sensor Applications: Synthesis and Characterization.
3. High-performance LPG detection by chemiresistive sensor using nanomaterials and their characterization.
4. Synthesis and Characterization of nanostructured material for Glucose Sensing Application.
5. Nanoparticle-Mediated Seed Priming Improves Germination, Growth, Yield, and Quality and their characterizations.
6. Preparation of nanoparticles and their application in antimicrobial activity.
7. Nanostructured Materials for Energy Related Applications: Synthesis and Characterization.
8. Nanostructured Materials for Water Purification: Synthesis and Characterization.
9. Study of acoustic and thermodynamic factors of synthesized nanomaterials by Nanofluidic Interferometer
10. Nanostructured Materials for the Development of Superhydrophobic Coatings.
11. Preparation of Self-assembly of nanostructures towards transparent, superhydrophobic surfaces for various applications.
12. Synthesis, Characterization, and Photocatalytic behaviour of nanocrystalline material.

2NTL12 SIMULATION LAB

Objective: The course is intended to cover understanding of simulation and modeling.

Course Outcomes:

1. To familiarize students about applying various material design and data analysis.
2. Quantum structures using online in- browser simulation tools.
3. To gain knowledge on design and construction of carbon molecules.
4. Student can develop math work and gain knowledge on Mat-Lab.
5. To maximize knowledge regarding 3D Printing and components.

Pre-requisite: Strategies to simplify the process of implementation.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

Experiments:

I. ARGUS LAB:

1. Construction of Bucky balls (C20, C40, C60, C80, C100, C120, C140)
2. Construction of Carbon nanotubes.

II. MATLAB:

1. Introduction to MATLAB Programming
2. Program assembly, Execution, Data processing and graphic analysis

III. NANOHUB:

1. BJT Lab
2. Carrier Statistics Lab
3. Drift-Diffusion Lab
4. MOSFET
5. PN Junction Lab

IV. 3 D PRINTING:

1. Materials Testing of 3D Printed PLA Samples to Guide Dog Bone Mechanical Design.
2. Electrode Substrate printing using conductive 3D Filament for electrical applications usingFDM Printer.
3. 3D high durable and flexible Face shield printing using ABS Filament for face protection

AUDIT COURSE:

1A02/2A03 ENGLISH FOR RESEARCH PAPER WRITING

Course Outcomes:

Students will be able to:

1. Understand that how to improve your writing skills and level of readability.
2. Learn about what to write in each section.
3. Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

UNIT II: Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.

UNIT III: Review of the Literature, Methods, Results, Discussion, Conclusions, the Final Check.

UNIT IV: Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature.

UNIT V: Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions.

UNIT VI: Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

References:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

AUDIT COURSE

1A02/2A03 DISASTER MANAGEMENT

Course Outcomes:

Students will be able to:

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical Relevance in specific types of disasters and conflict situations.
4. Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: INTRODUCTION: Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II: REPERCUSSIONS OF DISASTERS AND HAZARDS: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents,
Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

UNIT III: DISASTER PRONE AREAS IN INDIA: Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases And Epidemics.

UNIT IV: DISASTER PREPAREDNESS AND MANAGEMENT: Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

UNIT V: RISK ASSESSMENT: Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

UNIT VI: DISASTER MITIGATION: Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

AUDIT COURSE

1A02/2A03 SANSKRIT FOR TECHNICAL KNOWLEDGE

Course Outcomes:

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world.
2. Learning of Sanskrit to improve brain functioning.
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects.
4. Enhancing the memory power.
5. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences.

UNIT II: Order, Introduction of roots, technical information about Sanskrit Literature.

UNIT III: Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics.

Suggested reading:

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-VempatiKutumbshastri, Rashtriya Sanskrit Santhanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd. New Delhi.

Course Output:

Students will be able to

1. Understanding basic Sanskrit language.
2. Ancient Sanskrit literature about science & technology can be understood.
3. Being a logical language will help to develop logic in students.

Suggested Readings:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.
3. Goel S. L., Disaster Administration and Management Text And Case Studies", Deep &Deep Publication Pvt.Ltd., New Delhi.

AUDIT COURSE

1A02/2A03 VALUE EDUCATION

Outcomes:

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let they should know about the importance of character.
4. Knowledge of self-development.
5. Learn the importance of Human values.
6. Developing the overall personality

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: Values and self-development –Social values and individual attitudes, Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles, Value judgements.

UNIT II: Importance of cultivation of values. Sense of duty. Devotion, Self-reliance, Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity, Power of faith, National Unity. Patriotism. Love for nature, Discipline.

UNIT III: Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature.

UNIT IV: Character and Competence –Holy books vs Blind faith, Self-management, and good health Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self- control. Honesty, Studying effectively.

Suggested reading:

1. Chakraborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi.

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

AUDIT COURSE

1A02/2A03 CONSTITUTION OF INDIA

Course Outcomes:

Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a Civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals 'constitutional role and entitlement.to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.
4. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
5. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
6. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
7. Discuss the passage of the Hindu Code Bill of 1956.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: HISTORY OF MAKING OF THE INDIAN CONSTITUTION: History Drafting Committee, (Composition Working).

UNIT II: PHILOSOPHY OF THE INDIAN CONSTITUTION: Preamble Salient Features.

UNIT III: CONTOURS OF CONSTITUTIONAL RIGHTS & DUTIES: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV: ORGANS OF GOVERNANCE: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualification, Powers and Functions.

UNIT V: LOCAL ADMINISTRATION: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Panchayat raj: Introduction, PRI: Zila Panchayat. Elected officials and their roles, CEO Zila Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed Officials, Importance of grass root democracy.

UNIT VI: ELECTION COMMISSION: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Suggested reading:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexi.2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AUDIT COURSE

1A02/2A03 PEDAGOGY STUDIES

Course Outcomes:

Students will be able to:

1. Review existing evidence on the review topic to inform Programme design and policymaking undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.
3. What pedagogical practices are being used by teachers in formal and informal classrooms indeveloping countries?
4. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
5. How can teacher education (curriculum and practicum) and the school curriculum and Guidance materials best support effective pedagogy?

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and searching.

UNIT II: Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms
in developing countries. Curriculum, Teacher education.

UNIT III: Evidence on the effectiveness of pedagogical practices Methodology for the in-depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches, Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV: Professional development: alignment with classroom practices and follow-up, Support Peer support, Support from the head teacher and the community. Curriculum and assessment Barriers to learning: limited resources and large class sizes.

UNIT V: Research gaps and future directions Research design, Contexts, Pedagogy, Teacher education, Curriculum and Assessment, Dissemination, and research impact.

Suggested reading:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2):245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal ofCurriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher Educationresearch project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

AUDIT COURSE

1A02/2A03 STRESS MANAGEMENT BY YOGA

Objectives:

1. To achieve overall health of body and mind
2. To overcome stress

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: Definitions of Eight parts of yoga. (Ashtanga)

UNIT II: Yam and Niyam. Do's and Don't's in life. Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT III: Asan and Pranayama i) Various yoga poses and their benefits for mind & body, ii) Regularization of breathing techniques and its effects-Types of pranayama.

Suggested reading:

1. 'Yogic Asanas for Group Training-Part-I": Janardan Swami Yogabhyasi Mandal, Nagpur.
2. "Raja yoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AUDIT COURSE

1A02/2A03 PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Objectives:

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Course Outcomes:

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality andachieve the highest goal in life.
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity.
3. Study of Neetishatakam will help in developing versatile personality of students.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I: Neetisatakam-Holistic development of personality Verses- 19,20,21,22 (wisdom)Verses- 29,31,32 (pride & heroism) Verses- 26,28,63,65 (virtue)Verses- 52,53,59 (dont's Verses- 71,73,75,78 (do's)

UNIT II: Approach to day-to-day work and duties. Shrimad Bhagwad Geeta: Chapter 2- Verses 41, 47,48, Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23,35, Chapter 18-Verses 45, 46, 48.

UNIT III: Statements of basic knowledge. Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 – Verses 13, 14, 15, 16,17, 18 Personality of Role model, Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

Suggested reading:

1. "Shrimad Bhagavad Gita" by Swami Swarup Ananda Advaita Ashram (PublicationDepartment), Kolkata.
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P. Gopinath.
3. Rashtriya Sanskrit Sansthanam, New Delhi

3NTPE14 NANOTOXICOLOGY

Objective:

To learn and understand social impact and health issues of environmental pollution caused due Nano industries.

Course Outcomes:

1. To provide knowledge on social impact of nano industry.
2. To design and conduct experiments, as well as to analyze the results.
3. To enhance the various analytical techniques and to identify and solveproblems.
4. To understand the socio-ethical responsibility.
5. To know the importance of Dosimetry, Epidemiology and Toxicology of Nanoparticles.

Pre-requisite:

1. Basic Biology.
2. Basic Safety precautions.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I : POSSIBLE HEALTH IMPACT OF NANOMATERIALS

Sources of Nanoparticles; Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin; Nano particle Size - Surface and Body Distribution; Effect of Size and Surface Charges; Nanoparticles, Thrombosis and Lung Inflammation; Nanoparticles and Cellular Uptake; Nanoparticles and the Blood-Brain Barrier.

UNIT II : NANOMATERIALS FOR ENVIRONMENTAL REMEDIATION

Introduction- Nanoparticle-based Remediation Materials - Acid-Base Chemistry - Redox Chemistry- Field Deployments of ZVI - Absorption Chemistry - Hybrid Nanostructured Remediation Materials- Self-assembled Monolayers on Mesoporous Supports (SAMMS) - Functional CNTs.

UNIT III : BIOTOXICITY OF METAL OXIDE NANOPARTICLES AND CARBON NANOTUBES

Introduction; Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Nanomaterials and Biotoxicity; Iron Oxide; Titanium Dioxide; Dark Studies; UV Irradiation Studies; Other Metal Oxides; Toxicological Studies and Toxicity of Manufactured CNTs- case study; Toxicity of CNTs and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health.

UNIT IV : TOXICOLOGY OF NANOPARTILES IN ENVIRONMENTAL POLLUTION

Air Pollution; Introduction to Air Pollution Particles; Adverse Effects of PM in Epidemiological Studies; Role of Nanopartides in Mediating the Adverse Pulmonary Effects of PM; Effects of Nanopartides on the Cardiovascular System; Nanopartide Translocation and Direct Vascular Effects; Endothelial Dysfunction and Endogenous Fibrinolysis; Coagulation and Thrombosis; Cardiac Autonomic Dysfunction; Effects of Nanopartides on the Liver and Gastrointestinal Tract; Effects of NP on the Nervous System.

UNIT V : DOSIMETRY, EPIDEMIOLOGY AND TOXICOLOGY OF NANOPARTICLES

Epidemiological Evidence for Health Effect Associations with Ambient Particulate Matter; Toxicological Evidence for Ambient Particulate Matter Induced Adverse Health Effects; Inhaled Nanoparticle Dosimetry; Toxicological Plausibility of Health Effects Caused by Nanoparticles; Integrated Concept of Risk Assessment of Nanoparticles.

REFERENCES

1. Challa. S. S. R, Kumar, "Nanomaterials - Toxicity, Health and Environmental Issues", Wiley-VCH publisher, 2006.
2. Nancy. A, Monteiro-Riviere, Lang Tran. C, "Nanotoxicology: Characterization, Dosing and Health Effects", Informa healthcare, 2007.
3. Drobne. D, "Nanotoxicology for safe and Sustainable Nanotechnology", Dominant publisher, 2007.
4. ZafarNyamadzi. M, "A Reference handbook of nanotoxicology", Dominant publisher, 2008.

3NTPE14 SOCIETAL IMPACTS OF NANOTECHNOLOGY

Objective: To provide an adequate basic knowledge on social impact of Nanoscience and Nanotechnology

Course Outcomes:

1. To provide awareness to the engineering students about socio economic impact of nanotechnology andto handle
   the techniques effectively.
2. Understand the various social impacts of nanotechnology trend and research.
3. To enhance the nanotechnology research by taking ethics and public opinion into consideration.
4. To understand of professional and ethical responsibility.
5. To get awareness on Public Perceptions & Education

Pre-requisite:

1. Basic Ethics
2. Basic Economic impact and commercialization

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT I : PROTECTION & REGULATION FOR NANOTECHNOLOGY

Patentability requirements-riding the patent office pony-infringement issues-nanotech patents outside the united states-copyright requirements-nanotech creation as artist works-Delegation of power of agencies-Examples of regulation of nanotechnology-environmental regulations-regulation of exports-political and judicial control over agency action.

UNIT II : LIABILITY LEGAL ASPECTS OF NANOTECHNOLOGY

The applications of civil &criminal laws-civil liability, application of negligence to nanotechnology, strict liability for nanotechnology products-warranty-class actions-nanotechnology business organization-criminal liability

UNIT III :ECONOMIC IMPACTS AND COMMERCIALIZATION OF NANOTECHNOLOGY & SOCIAL SCENARIOS

Introduction -Socio-Economic Impact of Nanoscale Science: Initial Results and Nanobank-Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria -The Emerging NanoEconomy: Key Drivers, Challenges, and Opportunities-Transcending Moore's Law with Molecular Electronics and Nanotechnology- Navigating Nanotechnology Through Society -Nanotechnology, Surveillance, and Society: Methodological Issues and Innovations for Social Research-Nanotechnology: Societal Implications: Individual Perspectives-Nanotechnology and Social Trends-Five Nanotech

UNIT IV :ETHICS, LAW & GOVERNANCE

Ethics and Law-Ethical Issues in Nanoscience and Nanotechnology: Reflections and Suggestions-Ethics and Nano: A Survey-Law in a New Frontier- An Exploration of Patent Matters Associated with Nanotechnology - The Ethics of Ethics -Negotiations over Quality of Life in the Nanotechnology Initiative. Governance-Problems of Governance of Nanotechnology -Societal Implications of Emerging Science and Technologies: A Research Agenda for Science and Technology Studies (STS)-Institutional Impacts of Government Science Initiatives - Nanotechnology for National Security.

UNIT V : PUBLIC PERCEPTIONS & EDUCATION

Public Perceptions-Societal Implications of Nanoscience: An Agenda for Public Interaction Research - Communicating Nanotechnological Risks- A Proposal to Advance Understanding of Nanotechnology's Social Impacts -Nanotechnology in the Media: A Preliminary Analysis-Public Engagement with Nanoscale Science and Engineering -Nanotechnology: Moving Beyond Risk-Communication Streams and Nanotechnology: The (Re)Interpretation of a New Technology- Nanotechnology: Societal Implications — Individual Perspectives-Historical Comparisons for Anticipating Public Reactions to Nanotechnology.

REFERENCES

1. Mihail. C, Roco and William Sims Bainbridge "*Nanotechnology: Societal ImplicationsII-Individual Perspectives*", Springer ,2007.
2. Geoffrey Hunt and Michael. D, Mehta "*Nanotechnology: Risk, Ethics and Law*", Earthscan/James & James publication ,2006.
3. Jurgen Schulte "*Nanotechnology: Global Strategies, Industry Trends and Applications*", John Wiley &Sons Ltd ,2005.
4. Mark. R, Weisner and Jean-Yves Bottero "*Environmental Nanotechnology applications and impact of nanomaterial*", The McGraw-Hill Companies ,2007.

3NTPE14 SEMICONDUCTOR DEVICE TECIINOLOGY

Objectives:

The course is aimed to understand the physics of semiconductor materials and devices,working mechanism and design of optoelectronic devices.

Course Outcomes:

Students will be able to

1. To get sound awareness on semiconductor.
2. Students can able to acquire acquire knowledge of Metal-Semiconductor Contacts and Schottky Diodes.
3. To know the importance of Nanotechnology Pathways to Next-Generation Photovoltaics.
4. To develop knowledge on societal impact of semiconductor device technology.
5. To understand about Semiconductor Growth Technologies.

Pre-requisite:

1. Basic Electronics

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

UNIT 1: SEMICONDUCTOR: Energy Bands and Carrier Concentration in thermal Equilibrium: Semiconductor Materials, Basic Crystal Structure, Basic Crystal Growth Technique, Valence Bands, Energy Bands, Intrinsic Carrier Concentration, Donors and Acceptors. Carrier Transport Phenomena: Carrier Drift, Carrier Diffusion, Generation and Recombination Processes, Continuity Equation, Thermionic Emission Process, Tunneling Process, High-Field Effects.

UNIT 2: METAL-SEMICONDUCTORS: Metal-Semiconductor Contacts and Schottky Diodes: Metal-Semiconductor Junction diode Fabrication, Device Physics: Ideal MS contacts, Schottky Diode-Electrostatics, I-V characteristics, DC, AC and transient analysis. Metal-Semiconductor contacts: Ohmic contacts, Schottky contacts, Tunnel contacts and annealed and alloyed contacts. Photodiode Fabrication, device Physics of PN Junction Photodiodes, p-i-n Photo diodes. Principle of operation and fabrication technologies of Solar cell, LED, and LASER diodes. MOS capacitor, MOSFET device fabrication, MOSFET Physics: I-V characteristics, Sub-threshold region, Body effect, Capacitive effect, small and large signal model. MOSFET Short Channel effects: Punch through, DIBL, Hot electron effect, Velocity Saturation, Leakage current. MESFETs and MODFET analysis.

UNIT 3: NANOTECHNOLOGY PATHWAYS TO NEXT-GENERATION PHOTOVOLTAICS: Overview of Photovoltaics, Basic Principles, Photovoltaic Technologies: Quantum Wells and Superlattices, Nanowires, Nanoparticles and Quantum Dots, Dye-Sensitized Solar Cells, Nanostructures for Improved Optical Performance, Nanowire Solar Cells, Organic Nanostructures by Molecular Layer Epitaxy: Molecular Nanoelectronics, Methodology of Molecular Layer Epitaxy Size-Dependent Effects in MLE Structures.

UNIT 4: SEMICONDUCTOR DEVICE TECHNOLOGY AND ITS SOCIETAL IMPACT: Energy-efficient electron devices and the sustainable and green environment, Applications to safe and green environment, human health and medicine.

UNIT 5: SEMICONDUCTOR GROWTH TECHNOLOGIES: Bulk, Thin Films, and Nanostructures: Lely growth method, Liquid-phase epitaxy method, Pulsed-laser deposition technique, Molecular beam epitaxy growth technique.

Textbooks:

1. S. M. Sze and Ming-Kwei Lee, Semiconductor Devices Physics and technology, John Wiley & Sons, 2013.
2. Grundmann and Marius, Physics of Semiconductors, Springer, 2010.
3. Semiconductor Nanotechnology, Stephen M. Goodnick· AnatoliKorkin RobertNemanichSpringer series
4. Nano-Scaled Semiconductor Devices Physics, Modelling, Characterisation, and Societal Impact, Edmundo A. Gutie´rrez-D materials, Circuits & Devices Series 27 Nano-ScaledSemiconductor Devices
5. Semiconductor Heterojunctions and Nanostructures, Omar Manasreh MCGrawHill Nanoscience and Technology series.

Reference Books:

1. Ben G. Streetman and Sanjay Banerjee, Solid State Electronic Devices, Pearson Ed, 2014.
2. M. S. Tyagi, Introduction to semiconductor materials and devices, John Wiley & Sons, 2008.
3. Campbell, Stephan, Fabrication Engineering at the Micro and Nanoscale, OxfordUniversity Press, 2008.
4. Robert F. Pierret, Semiconductor Device Fundamentals, Pearson Education, 2006.
5. Richard C. Jaeger, Introduction to Microelectronic Fabrication, Prentice Hall, 2

3NTOE15 OPEN ELECTIVE: INDUSTRIAL SAFETY

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

UNIT-I: INDUSTRIAL SAFETY: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, washrooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc., Safety color codes. Fire prevention and firefighting, equipment, and methods.

UNIT-II: FUNDAMENTALS OF MAINTENANCE ENGINEERING: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT-III: WEAR AND CORROSION AND THEIR PREVENTION: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle, and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT-IV: FAULT TRACING: Fault tracing-concept and importance, decision tree concept, need andapplications, sequence of fault-finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT-V: PERIODIC AND PREVENTIVE MAINTENANCE: Periodic inspection-concept and need, degreasing, cleaning, and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program, and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

3NTOE15 OPEN ELECTIVE: WASTE TO ENERGY

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2

UNIT-I: INTRODUCTION TO ENERGY FROM WASTE: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

UNIT-II: BIOMASS PYROLYSIS: Pyrolysis – Types, slow fast – Manufacture of charcoal –Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT-III: BIOMASS GASIFICATION: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction, and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT-IV: BIOMASS COMBUSTION: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction, and operation - Operation of all the above biomass combustors.

UNIT-V: BIOGAS: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion -Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy Programme in India.

References:

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Handbook - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

3NTOE15 APPLICATIONS OF NANOTECHNOLOGY

Objective:

To familiarize students with basics of nanoscience and technology, Nanobiotechnologies and Nanomaterials for environmental and toxicology.

Course Outcomes:

1. To discuss the basic concepts of nano technology.
2. To understand the importance of nano biotechnology
3. To study the influence of nanotechnology in the field of environment and toxicology.
4. To evaluate the concepts of nano electronics.
5. To classify the applications of nano materials.

Pre-requisite:

2. Basic chemistry fundamentals
3. Basic material science

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3

UNIT-I: BACKGROUND OF NANOTECHNOLOGY: Scientific Revolutions, Nanotechnology and Nanomachines, The Periodic Table, Atomic Structure, Molecules and Phases, Energy, Molecular and Atomic size, Surfaces and Dimensional Space, Top down, and Bottom-up approach.

UNIT-II: NANOBIOTECHNOLOGIES: Concept-Structural principle of BioNanotechnology-Classification of Nanobiotechnologies -Micro- and Nanoelectromechanical Systems- Function of Biological Nano molecules- DNA computers and DNA microprocessors- Biotechnology based genetic engineering -Function of Biological Nanomolecules- Bio nanomachines in Action. Drug deliveries -Targeting Ligands based Drug Delivery- Cancer Treatment- Mediated Delivery - Tissue Regeneration, Growth and Repair, Tissue Bioengineering.

UNIT-III: NANO MATERIALS FOR ENVIRONMENT AND TOXICOLOGY : Green nanotechnology and its principles, Nano-convergence and Environmental Engineering, different environmental systems, Potential impacts of nanomaterials on organisms and ecosystems, Environmental applications, Nanotechnology and Our Energy Challenge of nanomaterials, Nanotechnology and Renewable Energy, Introduction to toxicology, principles of toxicology, Nanotoxicology, dosage-Response curve, classification of toxicity, factors affecting toxicity, LC50, LD 50, Air borne Particles.

UNIT-IV: NANOELECTRONICS: Approaches to nanoelectronics, Fabrication of integrated circuits, MEMS, NEMS, Nano circuits, Quantum wire, Quantum well, DNA-directed assembly and application in electronics.

UNIT-V: APPLICATIONS: Coatings, Optoelectronic Devices, Environmental Applications, Nanomedicine, Biomedical applications, Energy storage.

Textbooks:

1. Introduction to Nanotechnology by Charles P. Poole Jr and Frank J. Owens WileyIndia
2. Introduction to Nanoscience and Nanotechnology, Chatopadhyaya.K. and Banerjee A.N,
3. Introduction to nano tech by phanikumar
4. Nanotechnology and the Environment, Kathleen Sellers, Christopher Mackay, Lynn L. Bergeson, Stephen R. Clough, Marilyn Hoyt, Julie Chen, Kim Henry, Jane Hamblen, crc press, 2009.