Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in

Nanoscience and Nanotechnology

(Faculty of Science & Technology)

T.Y.B.Sc.

(Nanoscience and Nanotechnology)

(Semester Pattern)

To be implemented from Academic Year 2019-2020

ThirdYearB.Sc. Nanoscience and Nanotechnology

Patternof examination n:Semester

Theorycourses: Semester III: NNT331-NNT336 and Semester IV: NTT341-NTT346)

PracticalCourse:(EL337-EL339):Annual

Sr. No.	Sem-III	Sr. No.	Sem-IV
NNT331	Polymer and Composites	NNT341	Polymer Hetero-structures and their applications
NNT332	Nanophysics	NNT342	Functional Nanomaterials
NNT333	Nanobiotechnology	NNT343	ApplicationsofNanobiotechnology
NNT334	Carbon based Nanomaterials	NNT344	Nanoelectronics
NNT335	Energy Conversion Devices and Applications.	NNT345	Energy Storage Devices and Applications
NNT336	Environmental Nanotechnology and Applications.	NNT346	Photocatalasis for environmental pollution control

TheoryPapers					
Paper/Course No.	Title	TotalNumber of lectures PerSemester	Standardof passing		
			Internal marksoutof 10 (theory) Out of 20 (practicals)	External marksoutof 40 (theory) Out of 80 (practicals)	Totalpassing marksoutof 50 (theory) andoutof 100 (practicals)
SEM III					
NNT331	PaperI	48	4	16	20
NTT332	PaperII	48	4	16	20
NTT333	PaperIII	48	4	16	20
NTT334	PaperIV	48	4	16	20
NTT335	PaperV	48	4	16	20
NTT336	PaperVI	48	4	16	20
SEMIV					
NTT341	PaperI	48	4	16	20
NTT-342	PaperII	48	4	16	20
NTT343	PaperIII	48	4	16	20
NTT344	PaperIV	48	4	16	20
NTT345	PaperV	48	4	16	20
NTT346	PaperVI	48	4	16	20
PracticalPapers					
EL337 (SemesterIII &IV)	Practical PaperI	10Practicals of4lectures in each Semester (20/year)	08	32	40
EL348 (SemesterIII &IV)	Practical PaperII	10Practicals of4lectures in each Semester (20/year)	08	32	40
EL349 (SemesterIII &IV)	Project Practical PaperIII	10Practicals of4lectures in each Semester (20/year)	08	32	40

B.Sc. (Nanoscience and Nanotechnology) (Semester-III)
Paper Code: NTT331
Paper Title: Polymer Nanocomposite

Unit 1 - Synthesis of Polymer: **(12 lectures)**
Introduction to composite materials – Classification, Introduction to polymer composites – Nano, micro and macro scales – Reinforcements – Short fibre, long fibre and particulate fillers – Matrices – thermoplastics-thermosets and rubbers- Nano and micro composites**.**

Unit 2 - Synthesis of metal –polymer nanocomposites:**(12 Lectures)**

Incorporation of reinforcements in polymer solution mixing- latex stage mixing-melt mixing and in-situ polymerization and precipitation – Dispersion and nucleating effects-Intercalation and exfoliation- Application of layered and nonlayerednano and micro particles in polymer modification- Different methods of preparation of composites.

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Unit 3- Synthesis of Oxide/sulphide –polymer nanocomposites: **(12 Lectures)**

Carbon nanotubes- single walled and multi walled- preparation, treatment and functionalization Salient features of polymer modification with carbon nanotubes- nano silica and nano clay organically modified layered clays: various methods used for the incorporation of nano fillers in polymer matrix like solution mixing, latex stage mixing and melt mixing.

Unit 4- Applications of polymer nanocomposites : **(12 lectures)**

Characterization and testing of polymers and polymer composites- Thermal, mechanical and electrical properties- tribological characteristics- Fracture behaviour- Creep and Fatigue behaviour- Composite material rheology. Long term effects- Applications of composites.

Reference Books

1. G. Lubin - Handbook of composites – (Van Nostrand, 1982)
2. M.O.W. Richarson - Polymer Engineering Composites – (Applied Science Publishers, 1995)

3. J. G. Mohr - SPIE Handbook of Technology and Engineering of Reinforced Plastics/Composites – (Van Nostrand, 1998)

4. R. Krishnamoorti and R.A. Vaia – Polymer nanocomposites: Synthesis characterization and modeling (Americal Chemical Society, 2002)

5. Pinnavaia T.J. and Beall G.W. – Polymer –clay Nanocomposites (John Wiley 2000)

B.Sc. (Nanoscience and Nanotechnology) (Semester-III)
Paper Code: NTT332
Paper Title: Nanophysics

Unit 1 – Probability and distribution functions

(12 lectures)

Elementary probability theory: Preliminary concepts, Random walk problem, Binomial distribution, mean value, standard deviation, various moments, Gaussian distribution, Poisson distribution, mean value. Probability density and probability for continuous variables (brief),The laws of thermodynamics and their consequences (Brief), The problem of kinetic theory and phase space.

Unit 2 – Statistical Distribution of Systems of Particles: (12 Lectures)

Behaviour of density of states, Liouville theorem, Statistical equilibrium, ensemble, canonical ensemble, isolated systems, system in contact with heat bath. Quantum distribution function, Maxwell –Boltzmann statistics, Bose – Einstein statistics, Fermi-Dirac statistics, Specific heat models: classical and Einstein Specific Heat models.

Unit 3- Solid State Physics: (12 Lectures)

Revision of band theory, band structure, intrinsic and extrinsic semiconductors, Fermi level, band gap in metals, semiconductors and insulators, band gap for bulk, atoms and nanoclusters, density of states, Bohr exciton radius, quantum size effect, nanostructures, quantum well and quantum dots.

Unit 4- Advanced spectroscopy: (12 lectures)

Revision of electron probe microscopy, XPS, Dynamic Light scattering (DLS), NMR spectroscopy, ESR and FMR spectroscopy, optical absorption and emission spectroscopy, X-ray absorption fine structure, Photoluminescence, Thermoluminescence,

Reference Books

1. Fundamentals of Statistical Mechanics, B. B. Laud, New age International Publication, India.
2. Statistical and thermal Physics, F. Reif, Levant book, Kolkata, India.
3. An introduction to Statistical Mechanics and Thermal Physics, Robert H. Swendsen, Oxford University press.
4. Statistical Mechanics , R K Pathria and Paul D Beale, Elsevier (India)
5. Introduction to solid states Physics - Charles, Kittle 7th Edition
6. Introductory Solid States Physics – H. P. Myers
7. Solid States Physics - S.O. Pillai (latest edition)
8. Elementary Solid State Physics- M. Ali Omar
9. Solid States Physics – A.J. Dekkar

10. Fundamentals of Molecular Spectroscopy - C. N. Banwell,
11. Fundamentals of Molecular Spectroscopy - WALTER S. STRUVE
12. Introduction to Nanomaterials and nanotechnology by Vladimir Pokropivny,
13. Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007
14. Hari Singh Nalwa, “Encyclopedia of Nanotechnology”, USA 2011
15. James A. Schwarz, Cristian I. Contescu, Karol Putyera, “Dekker encyclopedia of nanoscience and nanotechnology” CRC Press, 2004.

B.Sc. (Nanoscience and Nanotechnology) (Semester-III)
Paper Code: NTT333
Paper Title: Nanobiotechnology

Unit 1 –Basic biomolecules: [12 Lectures]

Development of nanobiotechnology – timelines and progress, overview.

Basic biomolecules:

- Sugars: classification, occurrence, properties and biological reactions
- Proteins: Amino acids and peptides-classification, chemical reactions and physical properties. Peptide bond, Primary structure of proteins, structural comparison at secondary and tertiary levels
- Lipids: Classification, structure and functions. Triglycerides; Phospholipids; Steroids and terpenes. Glyco and lipoproteins-structure and function. Lipid Membranes: Structure and Properties - Models
- Nucleic acids: Structure of double stranded DNA (B, A, C, D, T and Z DNA). Physical properties of double stranded DNA, Types of RNAs and their biological significance, Conformational properties of polynucleotides.

Unit 2-Biological nanomaterial: [12 Lectures]

Biological nanoparticals and its applications :Introduction to biological nanoparticals, Exosomes, lipoproteins,Ferritin, Biological nanomoters and machines:

Biological nanomachines: protein assemblies, muscle myosin, ATPase, Haemoblobin,

Biological nanometers: Bacterial Flagella, cilia: Structure and function

Biological nanopores: Ion channels:bactriorhodopsin,

Bioinspired nanomaterial and its applications: DNA and protein based nanomaterial,Protein–Lipid Assembly, Interaction between biomolecules and nanoparticals surface.

Unit 3–Recombinant DNA technology: [12 Lectures]

Recombinant DNA technology:

Introduction, Restriction enzymes, cloning vectors (plasmids, bacteriophages, cosmids, expression), Transformation, PCR technique, Blotting techniques,(Southern blotting, Northern blotting and Western blotting),DNA sequencing: Maxam-Gilbert's method, Sanger's Dideoxy method, Automated DNA sequencing, Next generation sequencing, Hybridoma technology and production of monoclonal antibody, introduction to transgenic plants and animals and their application

Unit 4-Bioinformatics: [12 Lectures]

Concept of Genomics and proteomics

Introduction, Database and its classification, NCBI, Data retrieval tools, INTREZ, OMIN, BLAST, FASTA, Applications of Bioinformatics

Molecular modeling tools: Graphic visualization, structure and functional prediction, Protein folding prediction and the homology modeling, Docking simulation and Computer assisted molecular design.

List of Reference books:

1. Principles of Biochemistry, Lehninger , Nelson, Cox, CBS publishers and distributors, New Delhi, 2004.
2. Fundamentals of Biochemistry, Donald Voet, AkifUzman, Judith G. Voet, Charlotte W. Pratt, John Wiley and Sons, New York, 2008.
3. Biochemistry, Geoffrey L. Zubay , WCB publishers, 1998.
4. Biochemistry – LubertStryer, 1995. _
5. C. M. Niemeyer, C. A. Mirkin, ―Nanobiotechnology: Concepts, Applications and Perspectives‖, Wiley – VCH, (2004).
6. Nanoscience :Nanobiotechnology and Nanobiology, P. Boisseau, P. Houdy and M. Lahmani, Springer, 2007.
7. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology, Hari Singh Nalwa, American Scintific Publishers, 2005.
8. Nanobiotechnology, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004.
9. Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer,"Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact", Wiley – VCH, 2005.
10. Nicholas A. Kotov, "Nanoparticle Assemblies and Superstructures", CRC, 2006.
11. T. Pradeep, ―*Nano: The Essentials*‖, McGraw – Hill education, (2007).
12. David S Goodsell*, "Bionanotechnology*‖, John Wiley & Sons, (2004).
13. Molecular Biology of the Gene, 6th Edition (2008), James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Lodwick, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc. USA

14. Molecular Biotechnology: 4th edition. (2010), Glick B.R., Pasternak J.J., Patten C. L., ASM press, USA
15. Principles of Gene Manipulation & Genomics, 7th Edition (2006), Primrose and Twyman, Blackwell Publishing, USA.

B.Sc. (Nanoscience and Nanotechnology) (Semester-III)
Paper Code: NTT334
Paper Title: Carbon based Nanomaterials

Unit 1 - Forms of Carbon: **(12 lectures)**

Structure and bonding in Graphite, Diamond like Carbon(DLC) and other allotropes of carbon, carbon nanotubes and structure of C_{60}**.**

Unit 2 - Production of Carbon based nanomaterials: **(12 Lectures)**

Production of carbon nanotubes (Single walled and multiwalled) , arc discharge method, Laser ablation, Chemical vapour deposition, Pyrolatic technique, purification and separation of carbon nanotubes, diamond synthesis routes, preparation of nanodiamond.

Unit 3- Properties of carbon based nanomaterials: **(12 Lectures)**

Optical, Electrical, thermal and mechanical properties of different allotropes of carbon based nanomaterials.

Unit 4- Applications of carbon based nanomaterials: **(12 lectures)**

Catalysis applications of nanoforms of carbon, supercapacitor, battery applications, water purification, solar cell applications, sensor and FET, Biological applications.

Reference Books

1.Carbon materials and nanotechnology – Anke Krueger, Wiley- VCH publication
2. Carbon-based Nanomaterials and Hybrids, Hans J. Fecht, Kai Brühne, CRC Press
3. Carbon Nanotube Science, Peter J. F. Harris, Cambridge University Pres

4. Introduction to nanoscience – S. M. Lindsay, OXFORD publication
5. Nanostructured materials, C. C. Koch, 2006, William Andrew Inc
6. The Chemistry of Nanomaterials: Synthesis, Properties and Applications. C. N. R. Rao, A.Muller, A. K. Cheetham (Eds.), (2004) WILEY-VCH Verlag GmbH & Co., Weinheim

7. Nanostructured Materials, Jackie Yi-Ru Ying, 2001, Academamic press

8. Nanostructured materials, Philippe Knauth, JoopSchoonman, 2002, Springer

B.Sc. (Nanoscience and Nanotechnology) (Semester-III)
Paper Code: NTT335
Paper Title: Energy Conversion Devices and applications

Unit I: Photovoltaic Solar cells: (12 lectures)

Introduction to solar energy, the greenhouse effect, properties of sunlight, energy of photon, p-n junction under dark and under illumination, Light generated current, I-V equation, Characteristics, Upper limits of cell parameters, losses in solar cells, equivalent circuit, effects of various parameters on efficiency, Solar cell design, Design for high Isc, Antireflective coating (ARC), Design for high Voc and fill factor, Analytical techniques; solar simulator, Quantum efficiency, Minority carrier life time and diffusion length measurement. Design of Silicon solar cells, Thin film solar cells.

Unit 2: Sensitized Solar Cells: (12 lectures)

Introduction, Basics of photo-electrochemical cells, Construction, Mechanism of DSSCs, Energy band diagram, important parameters, properties of working electrode and counter electrode, properties of electrolytes and dyes, fabrication process, Operation, Efficiency, Degradation, Advantages, Disadvantages, Photocathodes and tandem cells, Development, New developments, various nanomaterials (TiO_2, ZnO, SnO_2), Introduction to quantum dot solar cells.

Unit 3: Polymer Solar Cells: (12 lectures)

Introduction, history of the polymer solar cells, planar heterojunction solar cells, bulk heterojunction solar cells, excitons in polymers, donor and acceptors polymers, mechanism of photon absorption and power generation, evolution of polymer solar cell designs, hybrid polymer solar cells, effect of addition of inorganic nanostructures in polymer solar cell, P3HT: PCBM solar cell.

Unit 4: Perovskite solar cells: (12 lectures)

Introduction, history of perovskite solar cells, work function of various contact materials, photo-physics of various perovskite materials, operation, design and working principal of perovskite solar cells, advantage and disadvantages of perovskite solar cells, comparison of photon conversion efficiency of perovskite solar cells with other solar cells.

Reference Books:

1. Solar photovoltaics, Fundamentals, Technologies and Applications by Chetan Singh Solanki, PHI Learning Private Limited, Delhi-110092.
2. Polymer photovoltaics, a practical approach by Fredrik C. Krebs, Spie Press, Bellingham, Washington USA.
3. Organic Solar Cells, Theory, Experiment, and Device Simulation by Wolfgang Tress, Springer.
4. Dye Sensitized Solar Cells by K. Kalyansundaram, EPFL Press, A Swiss academic publisher distributed by CRC press.
5. Solar cells- Dye-sensitized Devices by Leonid A. Kosyachenko, Published by Intech, Janeza Trdine 9, 51000 Rijeka, Croatia.

B.Sc. (Nanoscience and Nanotechnology) (Semester-III)
Paper Code: NTT336
Paper Title: Environmental Nanotechnology and Applications

Unit 1 – Water Pollution: (12 lectures)

1) Water Pollution, sources and management of water pollution, need for water management, waste water collection, physicochemical properties of waste water, water and waste water treatment, physical, chemical and biological treatment process, activated sludge, oxidation ditches, trickling filter, rotating discs, rotating drums, oxidation ponds, Anaerobic digestions, anaerobic filters, up flow anaerobic sludge blanket reactor, treatment schemes for water of dairy, distillery, sugar and antibiotic industries.
2) Ground water pollution, Sources, effect control, consequences of ground water pollution.
3) Drinking water, domestic and industrial waste water, nanotechnologies used in water treatments, effluent treatment.
4) Environment (Protection) act-1986, the water (prevention and control of pollution) act-1974

Unit 2 – Air pollution: (12 Lectures)

1) Air pollution, methods for the measurement of air pollution and its control, pollution in the atmosphere.
2) Toxicity due to air-borne nanomaterials, engineered nanomaterials in the environment and health effects of nanoparticles through air, absorption, pulmonary deposition of nanoparticles, elimination of dust deposited in the lungs, nanoparticles.
3) Absorption in the air, effect of ultrafine dust
4) The air (prevention and control of pollution) act-1981, clean air act and nanotechnology.

Unit 3- Nanomaterials for sensing toxic gases: (12 Lectures)

Gas sensing materials and devices, Techniques used for gas sensing (resistance, capacitance and electrochemical), Sensor properties, advantages of nanomaterials, synthesis and characterization of nano-metal oxides (tin oxide, zinc oxide, indium oxide),

mixed oxides, nanoscale materials for sensors (quantum dots, CNTs, nanotubes, wires and belts), colloidal silver and gold, magnetic nanoparticles, application of nanomaterials in sensors, CNT-based sensors, Grapehe-based sensors, active devices based on Nanostructures.

Unit 4- Mesoporous materials for Environmental Applications: (12 lectures)

Why mesoporous materials?, Hierarchy of solid structure and adsorption, mesoporous silica and its application to the absorption of toxic anions, important characteristics for Environmental applications, nanocomposites for environmental applications, CeO_2 catalysts and CO catalytic oxidation, metal loaded CeO_2/ZrO_2 catalysts, application of mesoporous TiO_2 in Photocatalysis, mesoporous materials as Adsorbents.

Reference Books:

1) Environmental applications of Nanomaterials: Synthesis, sorbents and sensors (2nd Edition) Editors: Glen E.Fryxell and Guozhong Cao, Imperial College Press
2) METAL OXIDE NANOSTRUCTURES AS GAS SENSING DEVICES, G. Eranna, CRC Press, A Taylor and Francis Book,
3) Environmental Chemistry, A. K. De, Wiley Western ltd. , New Delhi, 2003
4) Waste water Engineering- treatment, Disposal and reuse, Metcalf and Eddy, Inc., Tat McGraw Hill, 1999
5) Standard method by American public health association (APHA), 2005
6) Water and waste water analysis (Handbook of methods in environmental studies Col. 1 by S. K. Maiti, ABD Publication, Delhi, ISBN-978-81-8577-34-07

B.Sc. (Nanoscience and Nanotechnology) (Semester-III & IV)
Paper Code: EL337
Paper Title: PracticalPaperI

1. Synthesis of TiO_2- PVA nanocomposite.
2. Synthesis of ZnO-PANI nanocomposite.
3. Analysis of single wall carbon nanotubes, double wall and multi wall carbon nanotubes by Raman spectroscopy.
4. Surface Plasmon resonance studies by gold nanoparticles.
5. Photocatalytic degradation of methylene blue using TiO_2 nanoparticles.
6. Characteristic of solar cell as calculation of fill factor, maximum power point and efficiency.
7. Demonstration of H_2-O_2 fuel cells.
8. Analysis of cyclic Voltammogram and calculation of specific capacitance.
9. Synthesis of SnO_2 thin film for gas sensing applications.
10. Grain size estimation by using XRD.
11. Preparation of thick films by screen printing techniques.
12. Modeling and simulation of FINFET
13. Modeling of 1-D resonant tunneling devices.
14. Extraction of protein and estimation by lowezy's method.
15. Isolation of DNA from Bacteria/Plant/Animal material.
16. To study antibacterial/antifungal activity of nanomaterial.
17. Blast the nut/Protein sequence in database.
18. Scientific visit equivalent to four experiments with report submission by each student.

B.Sc. (Nanoscience and Nanotechnology) (Semester-III & IV)
Paper Code: EL348
Paper Title: PracticalPaperII

1. Synthesis of Ag-PANI nanocomposite.
2. Demonstration of quantum size effect (CdS nanoparticles).
3. Analysis of Graphene using Raman spectroscopy.
4. Surface Plasmon resonance studies of silver nanoparticles.
5. Photocatalytic degradation of azodye using ZnO nanoparticles.
6. Studies on Dye Sensitized Solar Cell.
7. Synthesis of NiO thin film for gas sensing applications.
8. Nanoparticles by thermal decomposition.
9. Surface area measurement using BET method and calculation of pore diameter, pore volume and surface area.
10. Analysis of surface morphology using SEM/FESEM/TEM/HRTEM.
11. Analysis of electrochemical impedance spectroscopy (EIS) and calculation of series resistance, equivalent resistance and capacitors.
12. Modeling and simulation of MESFET.
13. Studies on characteristic of LED and Photodiode.
14. Isolation of plasmid.
15. To study the cytotoxicity of nanomaterial using suitable material (Cell line/Insect culture/Ycant).
16. Restriction digesion and gel electrophoresis.
17. Scientific visit equivalent to four experiments with report submission by each student.

B.Sc. (Nanoscience and Nanotechnology) (Semester-III & IV)
Paper Code: EL349
Paper Title: Project Practical PaperIII

PROJECT BASED ON NANOSCIENCE / NANOTECHNOLOGY / APPLICATIONS OF NANOMATERIALS

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