Savitribai Phule Pune University

(Formerly University of Pune)

Three Year B.Sc. Degree Program in Nanoscience and Nanotechnology

(Faculty of Science & Technology)

S. Y. B. Sc. Nanoscience and Nanotechnology Syllabi in NEP

(Level 5.0)

National Education Policy Syllabus

To be implemented from Academic Year 2025-2026

Title of the program: B. Sc. (Nanoscience and Nanotechnology)

1) Programme Objectives:

The undergraduate (UG) degree course in Nanoscience and Nanotechnology aims to provide:

a) Knowledge and skills to undertake higher studies/research in Nanoscience and Nanotechnology and related interdisciplinary areas thereby enabling students' employment/entrepreneurship.

b) Critical and analytical thinking, scientific reasoning, problem-solving skills, communication skills and teamwork.

c) Competence and skill in solving both theoretical and applied Nanoscience and Nanotechnology problems.

d) In-depth knowledge in Nanoscience and Nanotechnology through understanding of key physical concepts, principles, theories and their manifestations.

e) Exposure to the latest advances in Nanoscience and Nanotechnology, allied disciplines and research.

f) A conducive learning environment to ensure cognitive development of students.

g) Sufficient subject matter competence and enable students to prepare for various competitive examinations such as UGC-CSIR NET/JRF, GATE, GRE, IIT-JAM, and Civil Services Examinations.

h) Moral and ethical awareness, leadership qualities, innovation and life-long learning.

i) Multicultural competence and multilinguist.

2) Program Outcomes:

The learning outcomes of the undergraduate degree course in Nanoscience are as follows:

1. Fundamental Knowledge: Students should acquire a solid understanding of the principles and concepts in nanoscience and nanotechnology. This includes knowledge of quantum mechanics, material science, chemistry, and physics at the nanoscale.

2. Experimental Skills: Students should gain hands-on experience in working with nanoscale materials and instruments, including microscopy techniques, nanofabrication, and characterization tools.

3. Interdisciplinary Approach: A B.Sc. program in Nanoscience and Nanotechnology should encourage interdisciplinary thinking and collaboration between various scientific fields, such as physics, chemistry, biology, and engineering.

4. Nanomaterials: Students should be able to identify and design nanomaterials with specific properties for various applications, such as electronics, medicine, and energy.

5. Safety and Ethical Considerations: Students should understand the safety and ethical implications of working with nanoscale materials and technologies.

6. Research Skills: The program should foster research skills, including the ability to design and conduct experiments, analyse data, and draw meaningful conclusions.

7. Problem-Solving: Graduates should be able to apply their knowledge and skills to solve real-world problems and address challenges in nanoscience and nanotechnology.

8. Communication: Students should develop strong communication skills, including the ability to present scientific findings and research effectively to both technical and non-technical audiences.

9. Nanotechnology Applications: Graduates should be familiar with various applications of nanotechnology in fields such as electronics, medicine, energy, and materials science.

10. Adaptability: Given the rapidly evolving nature of nanoscience and nanotechnology, students should be prepared to adapt to new technologies and discoveries in the field throughout their careers.

11. Advanced Education: The B.Sc. program may also prepare students for further education, such as pursuing a master's or Ph.D. in nanoscience or related fields.

Structure of Four Year-degree Program

Structure of the course for four years, the pattern of examination and question papers are as per Savitribai Phule Pune University:

Nanoscience and Nanotechnology as Major (Core) Subject and any other subject as Minor (each theory / practical paper has 2 credits).

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted
I 4.5/100	I	NS-101-TH	Introduction to Nanoscience	02
		NS-102-PR	Nanoscience and Nanotechnology Laboratory-I	02
	II	NS-151-TH	Material Science	02
		NS -152-PR	Nanoscience and Nanotechnology Laboratory-II	02
II 5.0/200	III	NS -201-MJ	Physical Techniques for synthesis of Nanomaterials	02
			Properties of Nanomaterials (Physical, chemical, Optical and	02
		NS -202-MJ	Magnetic)	02
			Nanoscience and Nanotechnology Laboratory-III	
		NS -203-MJ		
	IV	NS -251-MJ	Organic and polymer science of nanomaterials	02
		NS -252-MJ	Advanced Techniques for Characterization of Nanomaterials	02
			Nanoscience and Nanotechnology Laboratory-IV	
		NS -253-MJP		02
III 5.5/300	V	NS -301-MJ	Polymer and Composites	02
		NS -302-MJ	Nanophysics	02
		NS -303-MJ	Nanobiotechnology	02
		NS -304-MJ	Chemical and Biological Techniques for synthesis	02
			nanomaterials	
		NS -305-MJP	Nanoscience and Nanotechnology Laboratory-V	02
		NS -306-MJP	Nanoscience and Nanotechnology Laboratory-VI	02
	VI	NS -351-MJ	Polymer Hetero-structure and their applications	02
		NS -352-MJ	Functional Nanomaterials	02

		NS -353-MJ	Applications of Nanobiotechnology-II	**02**
		NS -354-MJ	Application of Nanotechnology-III	**02**
		NS -355-MJP	Nanoscience and Nanotechnology Laboratory -VII	**02**
		NS -356-MJP	Nanoscience and Nanotechnology Laboratory-VIII	**02**

List of major Electives:

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted
III 5.5/300	**V**	NS-310-MJ	Thin film technology	**02**
		NS-313-MJP	Practical (Thin film technology)	**02**
	VI	NS-360-MJ	Physics of Nanomaterials	**02**
		NS-361-MJP	Practical (Physics of Nanomaterials)	**02**

List of Vocational Skill Courses (VSC):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted
I	**I**	NS-121-VSC	Environment- I	**02**
	II	NS-171-VSC	Environment- II	**02**
II	**III**	NS-221-VSC	Data Analysis & Computer Application	**02**
	IV	NS-271-VSC	C Programing Practical	**02**
III	**V**	NS-321-VSC	Basic Instrumentation in Nanotechnology	**02**
	VI	NS-371-VSC	Basic Instrumentation Skill Practical	**02**

Field Project (FP) / On Job Training (OJT)/ Community Engagement Project (CEP):

Year	Sem.	Code Number	Title of the paper (Theory / Practical)	Credits allotted
II 5.0/200	**III**	NS-231-FP	Field Project	**02**
	IV	NS-281-CEP	Community Engagement Project	**02**
III 5.5/300	**V**	NS-331-FP/CEP	Field Project / Community Engagement Project	**02**
	VI	NS-381-OJT	On Job Training	**04**

Nanoscience and Nanotechnology as Major Subject and any other subject as Minor (each theory / practical paper has 2 credits)

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted
II 5.0/200	**III**	NS-241-MN	Renewable Energy and Energy Harvesting	**02**
		NS-242-MNP	Data Analysis & Computer Application Practical	**02**
	IV	NS-291-MN	Basics of Industrial Nanotechnology-I	**02**
		NS-292-MNP	C Programming Practical	**02**
III 5.5/300	**V**	NS-341-MN	Basics of Industrial Nanotechnology-II	**02**

List of Generic / Open Electives (OE):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted
I	**I**	OE-101-NS	Chemical and Biological technique for synthesis of nanomaterial	**02**

4.5/100	**II**	OE-151-NS	Basic Characterization Techniques	**02**
II **5.0/200**	**III**	OE-201-NS	Nanoscience and Nanotechnology in Daily Life	**02**
	IV	OEP-251-NS	Energy Conversion Devices and Applications	**02**

List of Skill Enhancement Courses (SEC):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted
I **4.5/100**	**I**	SEC-101-NS	C-Programming	**02**
	II	SEC-151-NS	Basic Instrumentation Skill	**02**
II **5.0/200**	**IV**	SEC-251-NS	Sensors and Detection Technology	**02**

Indian Knowledge System (IKS):

Year	Sem	Code Number	Title of the paper (Theory / Practical)	Credits allotted
I **4.5/100**	**I**	NS-101-IKS	Generic	**02**
II **5.0/200**	**III**	NS-201-IKS	नॅनोविज्ञान (Nanoscience)	**02**

Semester: - III

S. Y. B. Sc. (Nanoscience and Nanotechnology)

NS -201-MJ Physical Techniques for Synthesis of Nanomaterials

Lectures: 30 **(Credits-02)**

Module 1: Physical Methods (24 Lecturers)

a) Introduction

b) Mechanical techniques - Mechanical exfoliation using scotch tape, ultrasonic exfoliation, laser assisted exfoliation (mostly applicable to 2D nanomaterials), Ball Milling

c) Physical Vapour Deposition - Vacuum Evaporation, Sputter Deposition, Pulse Laser Deposition, Ion-beam Deposition (PLD), Molecular Beam Epitaxy (MBE) (mostly applicable for synthesis of nanostructures in thin film form), Electric-arc method (applicable for synthesis of nanostructures in powder form)

Module 2: Hybrid Techniques (combination of physical, chemical, and/or biological methods) (6 Lectures)

Metalorganic Chemical Vapour Deposition (MOCVD), Plasma Enhanced Chemical Vapour Deposition (PECVD), Laser irradiation in liquids (liquid phase plasma synthesis)

Module 3: Green Synthesis (Lectures 12)

Biological Synthesis of Nanoparticles, Microbial Routes for Nanoparticle Synthesis: - Actinomycetes, Algae, Bacteria, Fungi, Viruses, Yeasts, Biological Synthesis of Metal Nanoparticles via Plants. Factors Affecting Biological Synthesis of Metal Nanoparticles: - Influence of pH, Influence of Reactant Concentration, Influence of Reaction Time, Influence of Reaction Temperature. Major Nanoparticles Synthesized by Plant Extracts: - Gold and Silver Nanoparticles, Copper and Copper Oxide Nanoparticles, Palladium and Platinium Nanoparticles, Titanium Dioxide and Zinc Oxide Nanoparticles, Indium Oxide, Iron Oxide, Lead, and Selenium Nanoparticles. Applications of Nanoparticles & Biologically Inspired Templates.

Reference Books:

1. Nanotechnology: Principles & Practices. Sulbha K. Kulkarni, Capital Pub (3rd Edition)
2. Nanostructures and Nanomaterials Synthesis, Properties and Applications, Guozhong Cao, imperials college Press, London.
3. Nanaomaterils: Synthesis, properties and Applications. Edited by A. S. Edelstein & R. C. Commorata, Institute of Physics Publishing, Bristol & Philaldelphia.
4. Nanotechnology, Technology revolution of 21st Century by Er.Rakesh Rathi(S.Chand & company Ltd.

NS -202-MJ Properties of Nanomaterials (Physical, chemical, Optical and Magnetic)

Lectures: 30 **(Credits-02)**

Module 1: Physics at Nanoscale (10 Lecturers)

Quantum size effect, Bohr radius, surface energy, variation in band gap energy of semiconducting nanomaterials (blue and red shift), exciton.

Module 2: Properties of Nanomaterials: (08 lectures)

Mechanical properties - Hardness, Tribology, Elasticity, strength, etc.

Optical properties - Absorption, Transmission and Scattering of UV-visible radiation, Luminescence (Photoluminescence, Cathodoluminescence, Electroluminescence, etc) Surface Plasmon Resonance (SPR)

Magnetic properties - Diamagnetism, Para magnetism, Ferromagnetism, Ferri magnetism, Antiferro magnetism, Superpara magnetism, Giant Magnetoresistance (GMR) and Colossal Magnetoresistance (CMR)

Module 3: Introduction to Nanotoxicology: (Lectures 12)

Physicochemical determinants: Size Shape, Surface area Surface chemistry Material composition, Redox cycling and catalytic chemistry, UV activation leading to radical formation, Surface coatings for protection, passivation, hydrophobicity, hydrophilicity Effect of material synthesis methods, solvents etc NPs Degradation Routes of Exposure: oral respiratory tract, Skin, Gastrointestinal tract, injection, Risks evaluation both in vitro and in vivo studies, In vivo abnormal behavior, clinical signs, mortality, body weight changes, histological observation Histopathology, Immunohistochemistry, SEM, TEM, AFM

Spectroscopic techniques: AAS, X-ray fluorescence, SEM-EDS

Reference Books:

1) Nanotechnology: Principles & Practices. Sulbha K. Kulkarni, Capital Pub (3rd Edition)

2) Nanostructures and Nanomaterials Synthesis, Properties and Applications, Guozhong Cao, imperials college Press, London.

3) Nanomaterials: Synthesis, properties and Applications. Edited by A. S. Edelstein & R. C. Commorata, Institute of Physics Publishing, Bristol & Philaldelphia.

4) Nanomaterials by A.K. Bandyopadhyay (2nd Edition), International Publishers

NS -203-MJP Nanoscience and Nanotechnology Laboratory-III

Sr. No	Title of the experiment
1	Synthesis of SnO_2 nanoparticles by using Ball Milling method.
2	Preparation of TiO_2 thin films by using Spin Coating technique.
3	Preparation of CdS thin films by using Spray Pyrolysis method.
4	To determine Magnetic Susceptibility of $FeCl_3$ solution for different concentration
5	To determine band gap of TiO_2 using UV-Visible spectra.
6	Synthesis of Silver nanoparticles by using Plant Extract.
7	To study of X-ray Diffraction pattern to determine grain size of material. (Lattice Parameter)
8	Synthesis of ZnO nanoparticles by using Hydrothermal synthesis method.
9	To study of SAED (Selected Area Electron Diffratogram.)
10	To obtain porous silicon and study it's Photoluminescence.
11.	Synthesis of TiO_2 Using Sol-Gel method.
12.	Synthesis of ZnO using microwave synthesis method.
Activities	
1	Lab Visit (Equivalent to 2 Practical's)
2	Industrial Visit (Equivalent to 2 Practical's)

Minor

NS 241 MN Renewable Energy and Energy Harvesting

Lectures: 30 **(Credits-02)**

Module 1 : Fossil fuels and Alternate Sources of energy:

Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity.

Module 2: Solar energy:

Solar energy, its importance, storage of solar energy, solar pond, non plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

Module 3 : Wind Energy harvesting:

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

Module 4: Ocean Energy:

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

References

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi

2. Solar energy - M P Agarwal - S Chand and Co. Ltd.

3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.

4. Godfrey Boyle, “Renewable Energy, Power for a sustainable future”, 2004, Oxford University Press, in association with The Open University.

NS-242-MNP Data Analysis & Computer Application Practical

1. Plotting of various trigonometric functions using spread sheet/any graphic software viz. Microsoft Excel, Origin: sinx, cosx, tanx,ex, e-x, logx, lnx, xn

2. Plotting of conic sections using spreadsheet /any graphic software viz. Microsoft Excel, Origin: circle, ellipse, parabola, hyperbola

3. Inverse, determinant of matrix, solution of linear equations using Microsoft Excel or Origin software

4. Create various charts (line, bar, scatter, and pie) using tools like Excel, Python (Matplotlib/Seaborn), or Tableau.

5. Compute measures of dispersion (variance, standard deviation, range, interquartile range).

6. Perform basic operations in Excel/Google Sheets (sorting, filtering, conditional formatting).Use functions like VLOOKUP, HLOOKUP, Pivot Tables, and Goal Seek.

7. Implement basic formulas: SUM, AVERAGE, COUNTIF, and nested IF functions.

8. Perform hypothesis testing (t-test, chi-square test).

9. Choose a dataset and perform end-to-end analysis.

- Data cleaning
- Exploratory data analysis
- Statistical and predictive modeling
- Dashboard creation and presentation

10. Advanced Excel Techniques

- Create complex formulas and automate tasks with Excel Macros/VBA.
- Use data analysis add-ins like Solver and Analysis ToolPak.
- Generate dynamic dashboards.

11. Time Series Analysis

- Analyze and plot a time series dataset.
- Perform decomposition of time series (trend, seasonality, and residuals).
- Build a basic ARIMA model for forecasting.

VSC
NS 221 VSC Data Analysis & Computer Application

Lectures: 30 **(Credits-02)**

Module 1 :

Basic statistical functions and analysis – mean, median, mode standard deviation, correlation, regression methods & techniques, estimation Linear trend and growth rate.

Measures of central tendency: mean, median and mode; arithmetic, geometric and harmonic mean. Measures of dispersion, skewness and kurtosis. Correlation and regression.

Module 2 :

Introduction to probability theory. Notions of random experiment, sample space, event, probability of an event. Conditional probability. Independence of events. Random variables and probability distributions. Binomial and normal distributions. Estimation of population parameters from sample data.

Module 3 :

Basic components and organization of a computer, Generation and classification of computers, Input/Output devices, Data representation, Computer Software, Programming languages and packages.

Module 4 :

Familiarisation of MSExcel, Creating & Editing Worksheet, Formatting and Essential Operations, Formulas and Functions, and use of different Charts.

Readings

1. P.H. Karmel and M. Polasek (1978), Applied Statistics for Economists, 4th edition; Pitman.

2. M.R. Spiegel (2003), Theory and Problems of Probability and Statistics (Schaum Series).

3. Rajaraman, V. (1996) – Fundamentals of Computers, Prentice Hall (India) New Delhi

4. V.P.Jagi & S Jain (1996) – Computer for Beginners, Academic publisher, New Delhi

IKS

NS-201-IKS नॅनोविज्ञान (Nanoscience)

Lectures: 30 **(Credits-02)**

Module -1 नॅनो विज्ञान (Nanoscience):

1) नॅनो विज्ञानाचा परिचय (Introduction to Nanoscience)

2) आत्मिका अणुंच्या विशिष्टता (Uniqueness of Atomic Scale)

3) नॅनो स्केल गुणधि (Nanoscale Properties)

4) नॅनो विज्ञानाच्या तात्विक आणण कृततसमय (Fundamentals and Realities of Nanoscience)

5) नॅनो विज्ञानाच्या ि ूलशसदधाुंत (Fundamental Concepts in Nanoscience)

6) नॅनो तुंत्रज्ञानाच्या सिाजिास्त्र, नैततकता, आणण स ुिक्षा (Societal, Ethical, and Safety Aspects of Nanotechnology).

Module – 2 नॅनो टेक्नॉलॉजीची यशोगाथा (Nanotechnology Toolkit):

1) नॅनो डिव्हाइसेसचा डिझाइन आणण तनशिती (Design and Fabrication of Nanodevices)

2) नॅनो बायोटेक्नॉलॉजी (Nanobiotechnology)

3) नॅनो -इलेक्रॉतनक्स (Nanoelectronics)

4) नॅनो टेक्नॉलॉजीचे अन ुप्रयोग (Applications of Nanotechnology)

5) नॅनो ि टेरियल्सचा ि ापि इुंजतनअरिुंग, ि ोबोटटक्स, आणण इति क्षेत्रात (Engineering, Robotics, and Other Fields)

6) नॅनो ि ेडिशसन (Nanomedicine)

7) नॅनो एनजी (Nanoenergy).

Reference Book

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1) Nanotechnology: A Gentle Introduction to the Next Big Idea" by Mark A. Ratner and Daniel Ratner
2) Nanotechnology: An Introduction" by Jeremy Ramsden
3) Nanodhay :- Avachut Godbole

OE-201-NS Nanoscience and Nanotechnology in Daily Life

Lectures: 30 **(Credits-02)**

Unit 1 - Introduction to Nanoscience and Nanotechnology: (10 lectures)

Definition of nanoscience and nanotechnology, historical development, and significance of the nanoscale.

Understanding the Nanoscale: Size and scale comparison, nanometer size range, properties at the nanoscale (quantum effects, surface area).

Unit 2 - Fundamentals of Nanomaterials: (10 Lectures)

Types of nanomaterials (nanoparticles, nanowires, nanotubes), properties (optical, mechanical, electrical).

Unit 3 - Synthesis and Characterization Techniques for Nanomaterials: (10 Lectures)

Synthesis of Nanomaterials: Top-down vs bottom-up methods, common synthesis techniques (chemical vapor deposition, sol-gel process, etc.).

Techniques for analyzing nanomaterials: Scanning Electron Microscopy (SEM), Transmission Electron Microscope (TEM), Atomic Force Microscopy (AFM), X-ray diffraction (XRD), UV-Vis spectroscopy.

Unit 4- Applications of Nanotechnology: (10 lectures)

Medicine: Drug delivery systems, diagnostic tools, cancer treatment, and biosensors.

Nanoelectronics: transistors, quantum dots, MEMS, and NEMS in everyday electronics (smartphones, computers).

Energy and Environment: Nanomaterials in solar cells, batteries, supercapacitors, and water purification systems.

Consumer Products Examples: nano-coatings in textiles, self-cleaning surfaces, cosmetics, food packaging.

Reference Books

1. Introduction to Nanoscience and Nanotechnology" by Gabor L. Hornyak, Joydeep Dutta, H.F. Tibbals, and John J. Moore.
2. Nanotechnology: Principles and Practices" by S.K. Kulkarni.

SEMISTER-IV

NS-251 MJ Organic and polymer science of nanomaterials

Lectures: 30 **(Credits-02)**

Module 1: Basic Aspects Polymer Science: (12Lecturers)

Some basic definitions, Classification, Nomenclature

Polymerization methods: Mechanism of free radical, cationic and anionic polymerizations: Bulk, Solution, Suspension and Emulsion polymerizations, Interfacial condensation, Chemical (Oxidative) polymerization, electrochemical polymerization, Salient features of different polymerization techniques.

Molecular weight of polymers: Number average, weight average and viscosity average molecular weights of polymers- Determination of molecular weight of polymers by end group analysis and Viscometry methods.

Module 2: Some Special polymers: (12 Lecturers)

Bio-polymers: Bio-degradable polymers, Fire retardant/Thermally stable polymers, and Liquid Crystalline polymers.

Conducting Polymers: Discovery, Classification of conducting polymers (intrinsic and extrinsic conducting polymers). Chemical and electrochemical methods of the synthesis of conducting polymers, Structural characteristics and doping concept, charge carriers and conducting mechanism, Applications of conducting polymers

Module 3: Cabron Nanotubes and Graphene: (10 Lecturers)

Introduction to Carbon Nanotubes, Single-Wall Nanotubes, Multiwall Nanotubes, Synthesis of Carbon Nanotubes: Solid Carbon Source-Based techniques, Gaseous Carbon Source-Based techniques, Growth Mechanisms of Carbon Nanotubes: Catalyst-Free Growth, Catalyst-Free Growth, Activated Growth, Properties of Carbon Nanotubes, Applications

Introduction of Graphene and Reduced Graphene Oxide, Properties of Graphene, Applications

Module 4: Polymer Nanocomposites: (08 Lecturers)

Definition of nanocomposites:- Nanofillers, Classification of nanofillers, Synthesis and properties of nanofilers-Types of nanocomposites, Synthesis of nanocomposites: Direct mixing, solution mixing, In-situ polymerization -Polymer Metal oxide nanocomposites,

Polymer/CNTS and Polymer/Nanoclay based composites and their properties and functional applications.

References:

1. Bill Meyer, A Text Book of Polymer Chemistry, John Wiley & Sons, Singapore, 1994.
3. Gowariker and Visivanathan, Polymer Science, Wiley Eastern, 1986.
4. Nanostructured Conductive Polymers, Editor. Ali Efekhari, Wiley, 2010.
S. Nanocomposites Science and Technology M. Ajayan, L.S. Schadler, P. V. Braun
Wiley-VCH, 2004

NS-252 MJ Advanced Techniques for Characterization of Nanomaterials

Lectures: 30 **(Credits-02)**

Module 1: TDA, DSC, Fluorescence, Confocal Microscopy: (10 Lectures)

Working Principle, Block diagram of instrument, function and role of each block, Output form and its analysis, applications, Illustration by giving at least one typical example.

Module 2: Scanning Electron Microscope (SEM) and Energy Dispersive Analysis of X-rays (EDAX): (12 Lectures)

SEM: Working Principle, Block diagram of instrument, Function and role of each block, Interaction of electron beam, Output form and its analysis, limitations, applications. Different versions of SEM: FESEM, Environmental SEM, Biological sample preparation, Importance and applications.

EDAX: Working Principle data analysis and applications.

Module 3: Transmission Electron Microscope (TEM): (10 Lectures)

Construction, Working Principle, Image formation, Different Operational Modes: Bright field and Dark field imaging, High Resolution (HR) / Lattice mapping imaging, Selected Area Electron Diffraction (SAED), Illustration by showing typical TEM images obtained using the various operational modes

Sample preparation for TEM, Sample preparation for cross sectional view, Applications.

Module 4: Magnetic measurements (10 Lectures)

Vibrating Sample Magnetometer (VSM) – Construction, Working and applications, Introduction to Superconducting Quantum Interference Device (SQUID) – Construction, Working and Applications.

Reference Books:

1. Encyclopedia of Material Characterization Edited by C. Richard Brundle, Charles A. Evans, Shaun Wilson, Butterworth, London.
2. Handbook of Microscopy, Applications in Materials Science, Solid State Physics and Chemistry, Edited by D. van Dyck, J. van Landuyt and G. van Tendeloo VCH,UK.
3. Handbook of Instrumental Techniques for Analytical Chemistry, Edited by Frank A. Settle, Printice Hall, PTR, New Jersey, USA.
4. Instrumental Methods of Analysis, by Willard, Merritt, Dean and Settle, CBS Publishers & Distributors; 7th edition (2004)

5. Bharat Bhusan, “Springer Handbook of Nanotechnology”, springer, Newyork, 2007.
6. Hari Singh Nalwa, “Encyclopedia of Nanotechnology”,USA 2011.
7. James A. Schwarz, Cristian I. Contescu, Karol Putyera, “Dekker encyclopedia of Nanoscience and Nanotechnology” CRC Press, 2004.

NS 253 MJP Nanoscience and Nanotechnology Laboratory-2B

(Credits-2)

Sr. No	Title of the experiment
1	To obtain the design pattern on given substrate by using Photolithography.
2	Analysis of Surface morphology using SEM (Scanning Electron Microscopy).
3	Analysis of Surface morphology using TEM (Transmission Electron Microscopy).
4	Characterization of Graphene using Raman Spectroscopy.
5	Preparation of CdS Thin Film by using CBD method
6	Preparation of dye synthesized solar cell using Nano TiO_2 materials.
7	Study of dye synthesized Solar cell in the presence of Sunlight.
8	Synthesis of Copper and Copper Oxide Nanoparticles using plant extract.
9	Synthesis of Zinc Oxide Nanoparticles using plant extract.
10	Synthesis of Zinc Oxide by using Hydrothermal Method
11.	Study of elemental analysis by using EDAX
12.	Preparation of thick films by using screen printing techniques.
Activities	
1	Study of Atomic Absorption spectroscopy and FTIR (Equivalent to 2 Practical's)
2	Use of Anti plagiarism Software (Equivalent to 2 Practical's)

Minor

NS 291 MN Basic Industrial Nanotechnology

Lectures: 30 **(Credits-02)**

Module 1: Basics of Nanotechnology

- Introduction to nanotechnology and its significance.
- Nanoscale dimensions and quantum effects.
- Industrial relevance of nanotechnology.

Module 2: Nanomaterials

- Types of nanomaterials: Carbon-based, metal-based, ceramics, and composites.
- Properties of nanomaterials: Optical, electrical, mechanical, and thermal.
- Common synthesis techniques:
    - Top-down (e.g., milling, lithography).
    - Bottom-up (e.g., chemical vapor deposition, sol-gel process).

Module 3: Applications in Industry

- **Electronics**: Nanoelectronics, displays, memory devices.
- **Energy**: Batteries, solar cells, and fuel cells.
- **Healthcare**: Drug delivery systems, biosensors, and imaging.
- **Environment**: Water purification, air filters, and waste treatment.
- **Manufacturing**: Nanocoatings, thin films, and composites.

Module 4: Safety and Environmental Impact

- Potential risks and toxicology of nanomaterials.
- Environmental applications of nanotechnology.
- Regulatory and ethical considerations.

References

• Introduction to Nanotechnology by Charles P. Poole and Frank J. Owens.

• Nanostructures and Nanomaterials: Synthesis, Properties, and Applications by Guozhong Cao

NS-292-MNP C Programming Practical

(Credits-2)

1) Program to find factorial of given number.

2) Program to find prime number in given range.

3) Program to draw line, arc, circle, ellipse, rectangle, bar using computer graphics program.

4) Program to Find Binding energy of atom.

5) Program to Find displacement and velocity by using Kinematical equation.

6) Program to draw Simple Cubic structure.

7) Program to draw miller Indices.

8) Program to find root of equation using Newton-Rapson's method.

9) Program to find integration of given equation using Trapezoidal rule.

10) Program to find integration of given equation using $1/3^{rd}$ rule.

Reference Books:

1. Programming in C- (Schaum's series) Gottfreid TMH
2. Programming in C- Balgurusami Prentice Hall publications
3. Let us C- YashwantKanetkar BPB publications
4. Programming with C- K.R. Venugopal, S. R. Prasad, TMH.
5. Introductory methods of numerical analysis-S. Sastry Prentice Hall
6. Computer oriented numerical methods – V. Rajaraman.

OE-251-NS Energy Conversion Devices and Applications

Lectures: 30 **(Credits-02)**

Module 1: Photovoltaic Solar cells: (9 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. Minority carrier life time and diffusion length measurement. Design of Silicon solar cells, Thin film solar cells.

Module 2: Sensitized Solar Cells: (9 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, Advantages, Disadvantages, Introduction to quantum dot solar cells.

Module 3: Polymer Solar Cells: (6 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.

Module 4: Perovskite solar cells: (6 lectures)

Introduction, history of perovskite solar cells, 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.

SEC-251-NS Sensors and Detection Technology

Lectures: 30 **(Credits-02)**

Module 1. Introduction to Sensors and Detection Technology

- Definition of sensors, transducers, and detection systems.
- Classification of sensors: physical, chemical, biological, etc.
- Basic principles of sensing and detection.
- Importance and applications in industries like healthcare, automotive, IoT, and environmental monitoring.

Module 2. Sensor Characteristics and Performance

- Static characteristics: accuracy, precision, sensitivity, linearity, hysteresis.
- Dynamic characteristics: response time, bandwidth, and stability.
- Noise and signal-to-noise ratio.
- Calibration techniques and standards.

Module 3. Physical Sensors

- **Temperature Sensors:**
  - Thermocouples, Resistance Temperature Detectors (RTDs), Thermistors, Infrared Sensors.
- **Pressure Sensors:**
  - Strain gauges, piezoelectric pressure sensors, capacitive sensors.
- **Displacement and Position Sensors:**
  - Potentiometers, Linear Variable Differential Transformers (LVDTs), encoders.
- **Velocity and Acceleration Sensors:**
  - Accelerometers, gyroscopes, tachometers.

Module 4. Chemical and Biosensors

- **Chemical Sensors:**
  - pH sensors, gas sensors (e.g., CO2, methane), ion-selective electrodes.
- **Biosensors:**
  - Enzyme-based, DNA-based, and immunosensors.
  - Lab-on-chip technologies.
- Applications in healthcare (e.g., glucose monitoring, COVID-19 detection).

Reference books

1) Introduction to Sensors, John Fraden
2) "Sensors and Actuators: Engineering System Instrumentation" Clarence W. de Silva
3) "Handbook of Modern Sensors: Physics, Designs, and Applications" Jacob Fraden