SYLLABUS
For
MASTER PROGRAM (M. Sc.)
in
NANOSCIENCE AND NANOTECHNOLOGY

(w.e.f. 2026-27 and onwards)

Under

The National Education Policy, 2020 (NEP 2020)

DEPARTMENT OF PHYSICS
GURUKULA KANGRI (DEEMED TO BE UNIVERSITY)
HARIDWAR-249 404
Year 2026

PREAMBLE

Nanoscience is the study of systems in nanoscale and nanotechnology is the ability to systematically organize and manipulate properties and behavior of matter in the atomic and molecular levels. Nanotechnology is the application of nanoscience leading to the use of new nanomaterials and nanosize components in useful products. These newborn scientific disciplines are situated at the interface between physics, chemistry, materials science, microelectronics, biochemistry, and biotechnology and engineering. Through nanoscience and nanotechnology it has become possible to study and create very useful functional devices, materials and systems on the 1 to 100 nanometer (one billionth of a meter) length scale. The reasons why nanoscale has become so important are presented. Nanotechnology will eventually provide us with the ability to design custom-made materials and products with new enhanced properties, new nanoelectronics components, new types of "smart" medicines and sensors, and even interfaces between electronics and biological systems, nanodevices, nanorobotics, nanocomputers, nanopowders, nanostructured catalysts and nanoporous materials, molecular manufacturing, nanolayers, molecular nanotechnology, medicine such as Alzheimer's and cancer prediction, prevention and treatment through nanotechnology, nanobiology, organic nanostructures.

Master of Science (M.Sc.) in Nanoscience and Nanotechnology, the curricula, and course content were designed to meet the standards of UGC-CSIR (NET) and (SLET) examinations. The choice- based credit system of learning develops a strong base in the core subject and specializes in the disciplines of his / her liking and abilities and develops an in-depth understanding of various aspects of Nanotechnology. The students develop experimental skills, design, and implementation of novel synthetic methods, and develop the aptitude for academic and professional skills, by acquiring basic concepts for structural elucidation with hyphenated techniques, and understanding the fundamental biological process and rationale of the computer. The project introduced in the curriculum will motivate the students to pursue research and entrepreneurial skill development**.**

MEDIUM OF INSTRUCTION AND EXAMINATION:

The medium of instruction as well as examination will be in English.

ELIGIBLITY:

Any undergraduate science degree recognized by UGC.

THEORY EXAMINATION

The external evaluation will be based on the examination to be conducted by the university at the end of each semester.

PRACTICAL EXAMINATION

Practical examinations will be conducted at the end of each semester.

Evaluation:

A. Each paper carries an internal component.
B. There is a pass minimum of 40%.

GURUKULA KANGRI (DEEMED TO BE UNIVERSITY)

MISSION

- To create a synthesis of our Indian intellectual tradition with the best of modern education.
- Inculcating national spirit and respect for Indian culture among the students and society in order to contribute to the nation-building.
- Focusing on the personality of the students to be developed by value-based education.
- Enriching and empowering all the beneficiaries through the participative, positive, harmonious teaching-learning environment.
- Developing inter-linkages across teaching, research, and extension.
- Making students employable by imparting holistic education and developing skills.

CURRICULUM AND CREDIT FRAMEWORK FOR POSTGRADUATE PROGRAMMES-2024: EXCERPT

GRADUATE ATTRIBUTES OF PG PROGRAMMES

Qualifications that signify completion of the postgraduate degree are awarded to students who have demonstrated knowledge and understanding that is founded upon and extends and/or enhances that typically associated with the first cycle, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within a research context; ii) can apply their knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study; iii) have the ability to integrate knowledge and handle complexity, and formulate judgments with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgments; iv) can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously; v) have the learning skills to allow them to continue to study in a manner that may be largely self-directed or autonomous.

Accordingly, the NHEQF outlines the statement of learning achievements at a particular level on the basis of the following elements of descriptors:

- Knowledge and understanding
- General, technical, and professional skills required to perform and accomplish tasks
- Application of knowledge and skills
- Generic learning outcomes
- Constitutional, humanistic, ethical, and moral values
- Employability and job-ready skills, and entrepreneurship skills and capabilities/ qualities and mindset.

LEARNING OUTCOMES DESCRIPTORS FOR A HIGHER EDUCATION QUALIFICATION AT LEVEL 6 ON THE NHEQF

The Bachelor's degree (Honours/ Honours with Research) or the Post-Graduate Diploma is awarded to students who have demonstrated the achievement of the outcomes located at appropriate level on the NHEQF.

MASTER PROGRAM (M. Sc.) In Nano Science and Nano Technology	
Program Learning Outcomes (PLOs)	**Postgraduate Degree in Nano Science and Nano Technology**
After successfully earning the Postgraduate Degree in Nano Science and Nano Technology, the awardee will be able to:	
PLO-01: Knowledge & Understanding	**Demonstrate knowledge on the physics/chemistry/biotechnology and basics of nanoscale science and technology for their multifunctional applications.**
PLO-02: Experimental & Analytical Skills	**Demonstrate ability to synthesis and characterize the materials in general and also nanomaterials.**
PLO-03: Application of Knowledge & Skills	**Project their skill in lithography and nanofabrication.**
PLO-04: Critical Thinking & Problem-Solving	**Having expertise in processing of nanomaterials, MEMS and Bio MEMS as per needs and specifications.**
PLO-05: Lifelong Learning & Adaptability	**Demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks including material science, physics, chemistry and nanobiotechnology.**
PLO-06: Digital Literacy & Computational Proficiency	**Demonstrate skills to use synthesis, processing and imaging equipments to analyze samples.**
PLO-07: Research & Innovation Aptitude	**Able to propagate their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.**
PLO-08:	**Understanding the impact of nanomaterials on the society including environment, health and ecosystem.**
PLO-09:	**Able to plan and execute their own innovative ideas in the form of projects, product design and development.**
PLO-10:	**Develop confidence for self-education and ability for life-long learning.**

Programme Specific Outcomes (PSOs)	
PSO1	● Provide exposure in various specialization of Nanotechnology.
PSO2	● Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of phenomenon at nanoscale and nanosystems.
PSO3	● Engage in research and life-long learning to adapt to changing environment.
PSO4	● Having adaptive thinking and adaptability in relation to environmental context and sustainable development.
PSO5	● Having a clear understanding of professional and ethical responsibility.

Course Structure

The postgraduate program in Physics is a two-year degree meticulously designed with **Multiple Entry and Exit Points (MEES)**, in alignment with the National Education Policy (**NEP**) **2020**.

Program Structure:

S. No.	Award	Components	Credits Required
1.	PG Diploma	Coursework (CW)	44 Credits
2.	PG with Research	(CW + Research)	88 Credits

Multiple Entry and Exit System (MEES) Details:

The program's MEES framework provides flexibility, as detailed below:

Entry Points:

1. **First Year Entry (M.Sc. Year 1): Eligibility:** Applicants must hold any 3-three-year Bachelor of Science (B.Sc.) degree or B.E./B. Tech degree.
2. **Second Year Direct Entry (M.Sc. Year 2): Eligibility:** Applicants with a 4-year undergraduate degree B.Sc. (Honors/Research) or B.E./B. Tech degree.

Exit Points:

1. **After First Year (PG Diploma):** Students who successfully complete two semesters (totaling 44 credits) are eligible to exit the program with a Postgraduate Diploma in Physics.
2. **After Second Year (PG with Research):** Students who complete all four semesters, which includes a dedicated 20-credit research internship (totaling 88 credits), will earn a Postgraduate Degree with Research in Physics.

Course Structure for One Year in Physics (Programme Code: MNN)												
NCrf Credit Level	Semester		Core Papers (Core Course/Elective)		Course Level	Credit	Total Credits		Max. Marks			Credit Distribution
			Course Name	Course Code					Internal	End Sem	Total	L:T:P
6	Sem-I	Core	Introductory Physics (Core)	MNN26-C101	550	4	20	**22**	30	70	100	3:1:0
			Introductory Chemistry (Core)	MNN26-C102	550	4			30	70	100	3:1:0
			Introductory Biology (Core)	MNN26-C103	550	4			30	70	100	3:1:0
			Introduction to Material Science (Core)	MNN26-C104	550	4			30	70	100	3:1:0
			Lab-I (Nanoscience Lab) (Core)	MNN26-C151	550	4			30	70	100	0:0:4
		Elective – 1 (Select Any One)	Laboratory Safety and Health (Elective)	MNN26-E105	550	2	2		15	35	50	2:0:0
			Online SWAYAM Course (Optional)	MNN26-Y106	550	2			15	35	50	2:0:0
	Sem-II	Core	Introduction to Nanoscience and Nanotechnology (Core)	MNN26-C201	600	4	12	**22**	30	70	100	3:1:0
			Preparation of Nanomaterials (Core)	MNN26-C202	600	4			30	70	100	3:1:0
			Lab-II (Nanoscience Lab) (Core)	MNN26-C251	600	4			30	70	100	0:0:4
		Elective – 2 (Select Any One)	Characterization Techniques of Nanomaterials - I (Elective)	MNN26-E203	600	4	10		30	70	100	3:1:0
			Nanomedicine and Drug Delivery (Elective)	MNN26-E204	600	4			30	70	100	3:1:0
		Elective – 3 (Select Any One)	Nanobiotechnology (Elective)	MNN26-E205	600	4			30	70	100	3:1:0
			Introduction to Nanotoxicology (Elective)	MNN26-E206	600	4			30	70	100	3:1:0
		Elective – 4 (Select Any One)	Research Methodology (Elective)	MNN26-E207	600	2			15	35	50	2:0:0
			Online SWAYAM Course (Optional)	MNN26-Y208	600	2			15	35	50	2:0:0
Total Credit (First Year)								**44**				

Exit option with Post-Graduate Diploma in Physics on completion of courses equal to a minimum of 44 credits or Entry to One Year PG in Physics with coursework with Research.

NCrf Credit Level	Semester		Core Papers (Core Course/Elective)		Course Level	Credit	Total Credits		Max. Marks			Credit Distribution
			Course Name	Course Code					Internal	End Sem	Total	
6.5	Sem-III	Core	Nanoelectronics and Nanosensors (Core)	MNN26-C301	650	4	8	22	30	70	100	3:1:0
			Properties of Nanomaterials (Core)	MNN26-C302	650	4			30	70	100	3:1:0
		Elective – 5 (Select Any One)	Nanotechnology for Food and Agriculture (Elective)	MNN26-E303	650	4	14		30	70	100	3:1:0
			Biomedical Nanotechnology (Elective)	MNN26-E304	650	4			30	70	100	3:1:0
		Elective – 6 (Select Any One)	Basics of Pharmaceutical Sciences and Quality Audit (Elective)	MNN26-E305	650	4			30	70	100	3:1:0
			Industrial Nanotechnology (Elective)	MNN26-E306	650	4			30	70	100	3:1:0
		Elective – 7 (Select Any One)	Characterization Techniques of Nanomaterials – II (Elective)	MNN26-E307	650	2			15	35	50	2:0:0
			Advance Nanomaterials for Nanotechnology (Elective)	MNN26-E308	650	2			15	35	50	2:0:0
		Elective – 8 (Select Any One)	Lab-III (Nanoscience Lab) (Elective)	MNN26-E351	650	2			15	35	50	0:0:2
			Biomaterials and Nanobiotechnology for Tissue Engineering (Elective)	MNN26-E309	650	2			15	35	50	2:0:0
		Elective – 9 (Select Any One)	Green Manufacturing Technology (Elective)	MNN26-E310	650	2			15	35	50	2:0:0
			Internship/Academic Attachment (Skill) (Summer Term)	MNN26-I311	650	2			15	35	50	0:0:2
			Online SWAYAM Course (Optional)	MNN26-Y312	650	2			15	35	50	2:0:0
	Sem-IV		Dissertation/Internship (Internship)	MNN26-D471	700	20	22		150	350	500	0:0:20
			Online SWAYAM Course (Optional)	MNN26-Y401	700	2			15	35	50	2:0:0
	Total Credit (Aggregate)						**44**					
	Post-Graduate Degree in Physics with Research on completion of courses equal to 88 credits.											

Course Selection Guidelines:

- **SWAYAM Courses:** Students need to talk with the Head of the Physics Department (HOD Physics) before choosing any online SWAYAM courses.
- **Mandatory Courses:** All **Core Courses (C)**, **Laboratory Courses (L)**, **Skill Enhancement Courses (S)**, **Internship (I)**, and **Project (P)** are required. You don't have a choice for these.
- **Elective Courses:** You can choose your **Discipline-Centric Elective courses (E)** from a provided list. The total credits for these chosen electives must be:
  - **02 credits** for Semester I
  - **14 credits** for Semester III
  - **10 credits** for Semester II
  - **02 credits** for Semester IV (CW+R)

Semester-I

Course Type	Course Code	Course Name	Credits
Core Course (C) /Laboratory (L)	MNN26-C101	Introductory Physics	4
	MNN26-C102	Introductory Chemistry	4
	MNN26-C103	Introductory Biology	4
	MNN26-C104	Introduction to Material Science	4
	MNN26-C151	Lab-I (Nanoscience Lab)	4
		Total Core/Laboratory Credits	**20**
Discipline Centric Elective Course (E)		Elective -1	2
		Total Discipline Centric Elective Credits	**2**
Total Credits Semester-I			**22**

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- No. of Core Course (C) /Laboratory (L) to be opted = 04 (16 Credits Theory + 04 Credits Lab) = **20** credits
- No. of Discipline Centric Elective Papers to be opted = 01 (02 Credits each) = **02** Credits
- Total No. of Credits = **22** Credits

Semester-II

Course Type	Course Code	Course Name	Credits
Core Course (C) /Laboratory (L)	MNN26-C201	Introduction to Nanoscience and Nanotechnology	4
	MNN26-C202	Preparation of Nanomaterials	4
	MNN26-C251	Lab-II (Nanoscience Lab)	4
		Total Core/Laboratory Credits	**12**
Discipline Centric Elective Course (E)		Elective - 2	4
		Elective - 3	4
		Elective - 4	2
		Total Discipline Centric Elective Credits	**10**
Total Credits Semester-II			**22**

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- No. of Core Course (C) /Laboratory (L) to be opted = 03 (12 Credits Theory) = **12** credits
- No. of Discipline Centric Elective Papers to be opted = 03 (06 Credits Theory+04 Credits Lab) = **10** Credits

- Total No. of Credits = **22** Credits

Summer Term (Evaluation in the III semester)

Course Type	Course Code	Course Name	Credits
Summer Term	MNN26-I311	Internship/Academic Attachment	2
Total Credit			2

Semester-III

Course Type	Course Code	Course Name	Credits
Core Course (C) /Laboratory (L)	MNN26-C301	Nanoelectronics and Nano sensors	4
	MNN26-C302	Properties of Nanomaterials	4
		Total Major Core Credits	**8**
Discipline Centric Elective Course		Elective - 5	4
		Elective - 6	4
		Elective - 7	2
		Elective - 8	2
		Elective - 9	2
		Total Discipline Centric Elective Credits	**14**
Total Credits Semester-III			**22**

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- No. of Core Course (C) = 02 (08 Credits Theory) = **08** credits
- No. of Discipline Centric Elective Papers to be opted = 05 (08 Credits Theory+04 Credits Lab+02 Credits Internship) = **14** Credits
- Total No. of Credits = **22** Credits

Semester-IV (Research)

Course Type	Course Code	Course Name	Credits
Dissertation (D)	MNN26-D471	Dissertation/Internship	20
	MNN26-Y401	Online SWAYAM Course (No overlap with running courses)	02
Total Credits Semester-IV			**22**

Note: Students will choose online SWAYAM courses in consultation with HOD Physics

- Dissertation/Internship (D) = **20** credits
- Online Swayam Course(Y)=**02** Credits
- Total No. of Credits = **22** Credits

Total credit distribution for the Four semesters

CW+R					
	C/L	E	S	D/I	**Total credits (semester wise)**
Semester-I	20	02	0	0	**22**
Semester-II	12	10	0	0	**22**
Semester-III	08	12	0	2	**22**
Semester-IV	0	0	2	20	**22**
Total credits (Courses type)	40	24	2	22	**88**

Types of Courses:

- C - Core Course (C)
- L - Laboratory (L)
- E - Discipline Centric Elective Course (E)
- S - Skill Enhancement course (S)
- D – Internship/Dissertation (I)
- P - Project

* LIST OF ELECTIVES

Elective – I Sem			
Elective	**Course/Paper Code**	**Course/ Paper Name (02 Credit)**	**Credit**
Elective – 1 (Select Any One)	MNN26-E105	Laboratory Safety and Health	2
	MNN26-Y106	Online SWAYAM Course (No overlap with running courses)	2
Elective – II Sem			
Elective	**Course/Paper Code**	**Course/ Paper Name (06 Credit Theory + 04 Credit Lab)**	**Credit**
Elective – 2 (Select Any One)	MNN26-E203	Characterization Techniques of Nanomaterials - I	4
	MNN26-E204	Nanomedicine and Drug Delivery	4
Elective – 3 (Select Any One)	MNN26-E205	Nanobiotechnology	4
	MNN26-E206	Introduction to Nanotoxicology	4
Elective – 4 (Select Any One)	MNN26-E207	Research Methodology	2
	MNN26-Y208	Online SWAYAM Course (No overlap with running courses)	2
Elective – III Sem			
Elective	**Course/**	**Course/ Paper Name (10 Credit Theory + 04 Credit Lab)**	**Credit**
Elective – 5 (Select Any One)	MNN26-E303	Nanotechnology for Food and Agriculture	4
	MNN26-E304	Biomedical Nanotechnology	4
Elective – 6 (Select Any One)	MNN26-E305	Basics of Pharmaceutical Sciences and Quality Audit	4
	MNN26-E306	Industrial Nanotechnology	4
Elective – 7 (Select Any One)	MNN26-E307	Characterization Techniques of Nanomaterials - II	2
	MNN26-E308	Advance Nanomaterials for Nanotechnology	2
Elective – 8 (Select Any One)	MNN26-E351	Lab – III (Nanoscience Lab)	2
	MNN26-E309	Biomaterials and Nanobiotechnology for Tissue Engineering	2
Elective - 9 (Select Any One)	MNN26-E310	Green Manufacturing Technology	2
	MNN26-I311	Internship/Academic Attachment (Summer Term)	2
	MNN26-Y312	Online SWAYAM Course (No overlap with running courses)	2

Semester I

Course Code	Course Title				Type of Course
MNN26-C101	**Introductory Physics**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Understand fundamental concepts of physics which are necessary for nanoscience and technology subject.
- **CLO 2:** Apply the gained subject knowledge to understand the nano-enabled devices. Evaluate microscopic scales with macroscopic Impact with the help of Physics.
- **CLO 3:** Understanding on real time applications of physics.
- **CLO 4:** Analyze the acquired knowledge and understanding on real time applications of physics.

UNIT-I

Electromagnetic waves and their characteristics – Theories of light –Wave, Electromagnetic and Quantum – Scattering of light: Rayleigh's and Tyndal scattering – Huygen's principle – Interference – Diffraction – Polarization of light waves. **(10 Lectures)**

UNIT-II

Electric Current – Flow of Charges in Metals – Drift Velocity, Mobility and Their Relation – Ohm's Law: Electrical Resistance – I-V Characteristics – Resistivity and Conductivity – Superconductivity – Joule's Heating Effect – Thermoelectric Effects: Seebeck and Peltier Effect. Fundamental Concepts of Magnetism– Bohr Magneton- Magnetic Dipoles- Field- Electron Spin and Magnetic Moment- Magnetic moment due to Nuclear Spin- Magnetic dipoles- Permeability- Magnetization- Intensity of Magnetization – Magnetic Materials. **(20 Lectures)**

UNIT-III

Classification of Solids, Energy Levels, Intrinsic and Extrinsic Semiconductor, Conduction in Metals and Semiconductors. Diode Under Forward and Reverse Bias - Transistor Basics, Working Principles – Current-Voltage Characteristics. **(15 Lectures)**

UNIT-IV

De-Broglie wavelength: in terms of energy and potential – Schrödinger time dependent equation – Time independent equation – Applications of Schrödinger wave equation – One dimensional harmonic oscillator: Eigen values of the total energy – Particle in a one dimensional box. **(15 Lectures)**

Text Books / Reference Books:

1. Solid State Physics, S.O. Pillai, 4th Ed, New Age International Publishers (2001).
2. Introduction To Solid-State Physics, C. Kittel, Wiley (1986).
3. Magnetism: Principles and Applications, D. Craik, Wiley (1995).
4. A Textbook of Quantum Mechanics, P. M. Mathews and K. Venkatesan, Tata McGraw-Hill, (1978)
5. Quantum Mechanics: Theory and Applications, Ajoy Ghatak, and S. Lokanathan, Springer (2004)
6. Text Book Of Electronics, S. Chattopadhyay, New Central Book Agency pvt. Ltd., (2006).

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	2	2	2.2
2	3	2	2	3	3	2	3	2	2	2	2.2
3	3	2	2	3	3	3	3	3	3	2	2.7
4	2	2	2	2	2	2	2	3	2	2	2.1
Average PLO	2.75	2.25	2.25	2.5	2.5	2.25	2.5	2.75	2.25	2	2.3

High – 3, Medium – 2, Low - 1

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	2.2
2	3	2	3	2	1	2.2
3	3	2	2	2	2	2.2
4	3	2	3	2	2	2.4
Average PSO	3	2	2.75	2	1.5	2.25

Course Code	Course Title				Type of Course
MNN26-C102	**Introductory Chemistry**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Define and identify differential branches of chemistry and their importance. Understand and describe chemical concepts and processes.
- **CLO 2:** Interpretation and application of the theories to chemical process and derivations.
- **CLO 3:** Differentiate different properties and mechanisms of organic reactions, inorganic properties and physical concepts.
- **CLO 4:** Evaluation and assessment of the theories and chemical process for different applications.

UNIT - I

Chemical Equilibria - Activity Concept, Equilibrium Constant and Applications, Ionisation Constants of Acids and Bases. Concept Of pH, Hydrolysis of Salts. Buffers – Types, Range and Capacity, Dissociation of Polyprotic Acids, Common Ion Effect, Salt Effect. Electrochemistry – Conductivity of Electrolytes, Electrochemical Cells, Standard Electrode Potentials. **(15 Lectures)**

UNIT - II

Bonding Models in Chemistry – Ionic Bond, Covalent Bond, Theories of Bonding in Coordination Compounds-valence band theory-crystal field theory Electronic Spectra of Coordination Compounds. **(15 Lectures)**

UNIT - III

Thermodynamics: First, Second and Third Law of Thermodynamics. Gibbs And Helmholtz Energy - Chemical Equilibrium-Law of mass action- Arrhenius equation –Chemical Kinetics, Transition State Theory and Collision Theory, Heterogeneous Catalysis. **(15 Lectures)**

UNIT - IV

Structure of Organic Compounds – Electronic theory of Bonding-Tetrahedral model of carbon atoms-substitution reaction and its types- Free radical-Ionic- Electrophillic and nucleophilic reactions of Aromatic compounds-Elimination and addition reaction of Aromatic compounds. **(15 Lectures)**

Text Books/Reference Books:

1. Fundamentals Of Analytical Chemistry - Skoog, West and Holler, Saunders College, Publishing, VII Ed, (1996).
2. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IV Ed., (1985).
3. Physical Chemistry, A. Alberty And R.J. Silbey.
4. Inorganic Chemistry: Principles of Structure and Reactivity – J.E. Huheey, E.A. Keiter and R.L. Keiter, IV Ed.
5. Physical Chemistry, Atkins.
6. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed, Pearson Education Ltd, 2001.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	2	2	**2.2**
2	3	2	2	3	3	2	3	2	2	2	**2.2**
3	3	2	2	3	3	3	3	3	3	2	**2.7**
4	2	2	2	2	2	2	2	3	2	2	**2.1**
Average PLO	**2.75**	**2.25**	**2.25**	**2.5**	**2.5**	**2.25**	**2.5**	**2.75**	**2.25**	**2**	**2.3**

High – 3, Medium – 2, Low - 1

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
3	3	2	2	2	2	**2.2**
4	3	2	3	2	2	**2.4**
Average PSO	**3**	**2**	**2.75**	**2**	**1.5**	**2.25**

Course Code		Course Title			Type of Course
MNN26-C103		**Introductory Biology**			**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO1**: Acquire the knowledge of the cell biology and application. Explain the role of cell organelles, metabolism, and bioenergetics.
- **CLO2:** Understand the about the morphology, structure, of DNA, RNA and different types of nucleic acid.
- **CLO3:** Gain the knowledge about of glucose, and fatty acid metabolism.
- **CLO4:** Evaluate and compare of the different enzyme role energy production.

UNIT-I

Definitions, Types, Eukaryotic and Prokaryotic cells, Principle of membrane organization, Cytoskeletal proteins, Types of cell division, Mitosis and Meiosis. Structure and functions of proteins, Amino acids and peptides, Proteins-Primary Secondary, Tertiary, and Quaternary structures, Protein folding, hemoglobin and myoglobin. **(15 Lectures)**

UNIT-II

Mechanism of actions, Enzyme kinetics, Regulation of activities, Bioenergetics, Role of ATP, Biological oxidation, Respiratory chain and oxidative phosphorylation. **(15 Lectures)**

UNIT-III

Overview of metabolism and catabolism, Carbohydrates, Glycolysis, Lipids of physiological significance, Cholesterol, Synthesis, Transport and Excretion, Glycoproteins, Biooxidation, Fatty acid synthesis, Phospholipids. **(15 Lectures)**

UNIT-IV

Structure, functions and replications of information macromolecules. Metabolism of purines and pyrimidine nucleotides. Organization, replication and repair of DNA. RNA and protein synthesis. **(15 Lectures)**

Text Books/Reference Books:

1. Lehninger, Principles of Biochemistry, Cox and Nelson, V Edn, 2008.
2. L. Stryer, Biochemistry, 4th Edn., 1995.
3. Haper's Illustrated Biochemistry, R.K, Murray, D.K. Granner and V.W. Rodwell, McGraw Hill, New Delhi, 2003.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	2	2	**2.2**
2	3	2	2	3	3	2	3	2	2	2	**2.2**
3	3	2	2	3	3	3	3	3	3	2	**2.7**
4	2	2	2	2	2	2	2	3	2	2	**2.1**
Average PLO	**2.75**	**2.25**	**2.25**	**2.5**	**2.5**	**2.25**	**2.5**	**2.75**	**2.25**	**2**	**2.3**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
3	3	2	2	2	2	**2.2**
4	3	2	3	2	2	**2.4**
Average PSO	**3**	**2**	**2.75**	**2**	**1.5**	**2.25**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-C104	**Introduction to Material Science**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO1**: Understand the fundamental concepts of material science.
- **CLO2:** Apply the gained subject knowledge to understand the advanced concepts of nanoscience. Evaluate the impact of presence of impurity and applied temperature on various properties of materials.
- **CLO3:** Analyze the acquired knowledge and understanding on real time applications of various functional materials
- **CLO4:** Evaluate the different in the types of materials.

UNIT-I

Structure of Matter- Amorphous, Crystalline, Crystals, Polycrystals, Symmetry, Unit Cells, Crystal Structures, Crystallographic Planes, Miller Indices, Chemical Bonding, Atomic Bonding in Solids, Types of Bonds: Metallic, Ionic, Covalent and Vander Waals; Crystal Defects. **(10 Lectures)**

UNIT-II

Origin of Band Gap in Solids – Concept of Effective Mass of Electron and Hole – Band Gap Determination – Electrical Conductivity – Activation Energy – Carrier Concentration in Semiconductors – Effect of Temperature and Impurity on Fermi Level – Hall Effect: Determination of Hall Coefficient. Magnetic Materials – Dia, Para, Ferro, Anti-Ferro and Ferri Magnetism – Magnetic Susceptibility –Curie and Neel Transition Temperature – Hysteresis – Remanence – Coercivity – Saturation Magnetization –Origin of Domain theory- Ferrites – Magnetic Recording and Readout – Storage of Data – Tapes and Floppy - Magnetic Disk Drives. **(20 Lectures)**

UNIT- III

Dielectric Materials: Electronic, Ionic, Orientational, and Space Charge Polarization – Complex Dielectric Constant, RC Equivalent Network – Dielectric Loss – Different Types of Dielectric Breakdown, Classification of Insulating Materials. **(10 Lectures)**

UNIT- IV

Thermal: Heat Capacity – Thermal Expansion – Thermal Conductivity and Stresses – Optical Properties of Metals and Non-Metals. Application of Optical Phenomena – Mechanical Properties: Elastic and Plastic Deformation – Interpretation of Stress-Strain Curves, Compressive Strength –Hardness: Rockwell, Brinell and Vickers. **(20 Lectures)**

Text Books / Reference Books:

1. Solid State Physics, S.O. Pillai, 4th Ed, New Age International Publishers (2001).
2. Introduction To Solid-State Physics, C. Kittel, Wiley (1986).
3. Magnetism: Principles and Applications, D. Craik, Wiley (1995).
4. Impedance Spectroscopy: Theory, Experiment, and Applications, 3rd Edition, Dr. Evgenij Barsoukov and Dr. J. Ross Macdonald, Wiley (2018).
5. Solid-State Physics: Introduction to the Theory, Patterson, James, Bailey, Bernard C. Springer (2018).
6. Magnetic Materials: Fundamentals And Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018).
7. NPTEL: Material Science https://nptel.ac.in/courses/112/108/112108150/
8. NPTEL: Magnetic Properties https://www.youtube.com/watch?v=QQZ6EGf0Ju8.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	2	2	**2.2**
2	3	2	2	3	3	2	3	2	2	2	**2.2**
3	3	2	2	3	3	3	3	3	3	2	**2.7**
4	2	2	2	2	2	2	2	3	2	2	**2.1**
Average PLO	**2.75**	**2.25**	**2.25**	**2.5**	**2.5**	**2.25**	**2.5**	**2.75**	**2.25**	**2**	**2.3**

High – 3, Medium – 2, Low - 1

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
3	3	2	2	2	2	**2.2**
4	3	2	3	2	2	**2.4**
Average PSO	**3**	**2**	**2.75**	**2**	**1.5**	**2.25**

Course Code	Course Title				Type of Course
MNN26-C151	**Lab-I (Nanoscience Lab)**				**Laboratory**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
0	**0**	**4**	**4**	**100**	**120**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Acquire practical skills in the use of instruments, technologies and methods in biomolecules like glucose, proteins. Gain practical knowledge by applying the experimental methods to correlate with the theory.
- **CLO 2:** Provides opportunities to collect and examine samples from blood and cells.
- **CLO 3:** Identify the acidic and bases values of the chemicals.
- **CLO 4:** Understand the basic characteristics of the electronic devices.

List of Experiments –

1. Find out the Rf-value of amino acids using Paper Chromatography.
2. Estimate the protein concentration of the given sample by Lowry's Method.
3. Estimation of Blood Glucose Level and Blood Group Analysis.
4. Curve Fitting Analysis for a Given Experimental Data Set.
5. Study the Forward and Reverse Characteristics of P–N Junction Diode and Zener Diode.
6. Study the Characteristics of Bipolar Junction Transistor (BJT) in CE, CB and CC Configurations.
7. Measurement of DC Conductivity using Two-Probe Method.
8. Determination of DNA Concentration using UV–Visible Spectrophotometry.
9. Verification of Beer–Lambert Law and Estimation of Unknown Sample Concentration.
10. Measurement of pH and Electrical Conductivity of Biological Solutions.
11. Study of V–I Characteristics of Light Emitting Diodes (LEDs).
12. Verification of Ohm's Law and Measurement of Resistance using Digital Multimeter.
13. Study of Operational Amplifier as Inverting and Non-Inverting Amplifier.
14. Calibration of Thermistor/RTD and Measurement of Temperature.
15. Measurement of Optical Absorption Spectrum and Determination of λmax using UV–Visible Spectrophotometer.
16. Recording and Analysis of ECG Signals using an ECG Simulator/Biopotential Acquisition System.
17. Statistical Data Analysis, Regression, and Error Analysis using Excel/Origin/MATLAB.

Note -

1. Students are required to perform any **1 5** experiments from the above list.
2. In practical examination the student shall be required to perform **Two** experiments from the list.
3. Experiment shall carry **40 Marks** and **20 Marks** shall be assigned for viva-voce examination. **10** Marks shall be reserved for practical record.
4. No batch for practical class shall consist of more than **20** students.
5. The number of students in a batch allotted to an examiner for practical examination shall not exceed **12-15** students.
6. Addition/deletion in the above list of **some experiments of similar nature** may be made in accordance with the facilities available with the approval of **H.O.D**.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	2	1	2	**2.2**
2	3	3	3	3	3	2	3	1	2	2	**2.5**
3	3	3	3	3	3	3	3	2	3	2	**2.8**
4	3	3	3	3	2	2	2	2	1	1	**2.2**
Average PLO	**3**	**3**	**3**	**2.75**	**2.5**	**2.25**	**2.5**	**1.75**	**1.75**	**1.75**	**2.42**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	2	2	1	**2.2**
2	3	3	2	2	1	**2.2**
3	3	3	2	2	2	**2.4**
4	3	3	3	2	2	**2.6**
Average PSO	**3**	**3**	**2.25**	**2**	**1.5**	**2.35**

High – 3, Medium – 2, Low - 1

Course Code		Course Title			Type of Course
MNN26-E105		**Laboratory Safety and Health**			**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**30**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Understand and describe various safety issues and protocols. Interpretation and application of safety protocols and laboratory rules. Differentiate different types of laboratory accidents and safety protocols and personal protective equipments.
- **CLO 2:** Evaluation and assessment of chemical, biosafety regulations, personal protective equipments and First aid practices. Apply the safety practices in real-time and awareness to the societal needs.

UNIT I

Standard Laboratory Procedures, Rules and Regulations. Lab Safety Practices. Employee Information, Safety Plans and Arrangement of Laboratories. Various Safety Equipments, Personal Protective Equipments, User Manuals, Arrangements, Training. **(15 Lectures)**

UNIT II

Chemicals Handing, MSDS Information, Labelling of The Chemicals, Disposal of the Chemical and Biological Wastes. First Aid Practices - Cardiac, Chemical Injury, Physical Injury. Emergency Calls and Procedures. First Aid Kits. **(15 Lectures)**

Text Books/Reference Books:

1. Introduction To Health and Safety at Work, Elsevier (2015).
2. Environmental Health & Safety Procedure Manual, Harper College (2001).

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	2	2	3	2	2	2	2	3	1	1	**2**
2	2	2	2	3	3	2	3	1	2	2	**2.2**
Average PLO	**2**	**2**	**2.5**	**2.5**	**2.5**	**2**	**2.5**	**2**	**1.5**	**1.5**	**2.1**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	2	2	3	2	1	**2**
2	2	2	3	2	1	**2**
Average PSO	**2**	**2**	**3**	**2**	**1**	**2**

High – 3, Medium – 2, Low - 1

Semester II

Course Code	Course Title				Type of Course
MNN26-C201	**Introduction to Nanoscience and Nanotechnology**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Understand the fundamental concepts of nanoscience. Apply the basic concepts of physics, chemistry and biology concepts to understand the advanced concepts of nanoscience.
- **CLO 2:** Analyze the influence of size and morphology and other factors on various properties of materials.
- **CLO 3:** Analyze the acquired knowledge and understanding of nanoscience in various field.
- **CLO 4:** Evaluate and assess the theories related to nanoscience for different applications.

UNIT-I FUNDAMENTALS AND BASIC CONCEPTS

Background to nanoscience – Historical perspectives and Scientific revolutions – Definitions and classifications based on dimension: Zero, One, Two and Three - Clusters, Quantum dots, Nanowires, Rods and tubes, and thin films; Hard sphere model: Grain and Grain boundary concepts; Top-Down and Bottom-Up Approaches: Physical - Chemical and Mechanical Routes; Influence of various parameters on morphology of crystallites - Nanocomposites: Metal and Metal Oxides; Metal. **(15 Lectures)**

UNIT-II UNIQUE PROPERTIES

Quantum Confinement Effects: Influence of grain size and morphology – Physical properties with Uniqueness compared to bulk and microscopic solids: Optical – Surface Plasmon Resonance, Band Gap Widening, Magnetic – Super para magnetism, Thermal –Melting point depression. **(15 Lectures)**

UNIT-III ADVANCED NANOSTRUCTURED MATERIALS

Allotropes of carbon: Graphene, CNT, C-dots, Fullerenes – Inorganic: Organic hybrids –Ferrofluids-Zeolites- Core-shells – Nanostructures of Zinc Oxide: tetra pods, rings, springs, belt, rods, wires -Additive Manufacturing of 3D Nano architected Metals – Nanorobots. **(15 Lectures)**

UNIT-IV ROAD MAP

Miniaturization of electronic materials and devices – Lithography techniques - Scaling issues – batch fabrication and circuit integration – MEMS and NEMS – Current and future challenges. **(15 Lectures)**

Text Books / Reference Books:

1. Solid State Physics, S.O. Pillai, 4th Ed, New Age International Publishers (2001).
2. Introduction To Solid-State Physics, C. Kittel, Wiley (1986).
3. Magnetism: Principles and Applications, D. Craik, Wiley (1995).
4. Springer Handbook of Nanotechnology, Edited by Bharat Bhushan, Springer (2006)
5. NANO: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill (2017)
6. Magnetic Materials: Fundamentals and Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)
7. NPTEL: Introduction to Nanomaterials https://nptel.ac.in/courses/118/104/118104008/
8. NPTEL: Nanostructuresd Materials
9. https://nptel.ac.in/courses/118/102/118102003/

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	3	3	2	2	3	1	1	**2.4**
2	3	3	3	3	3	2	3	1	2	2	**2.5**
3	3	3	3	3	3	3	3	3	3	2	**2.9**
4	3	3	3	3	3	2	2	3	1	1	**2.4**
Average PLO	**3**	**3**	**3**	**3**	**2.5**	**2.25**	**2.5**	**2.5**	**1.75**	**1.5**	**2.55**

High – 3, Medium – 2, Low - 1

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	**2.4**
2	3	3	3	2	1	**2.4**
3	3	3	2	2	2	**2.4**
4	3	3	3	2	2	**2.6**
Average PSO	**3**	**3**	**2.75**	**2**	**1.5**	**2.45**

Course Code	Course Title				Type of Course
MNN26-C202	**Preparation of Nanomaterials**				**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Understand the fundamental concepts in materials preparation with various Morphologies. Apply the gained subject knowledge towards understanding the mechanisms involved in physical, chemical and mechanical routes.
- **CLO 2:** Evaluate and understand the role of preparation method towards grain with narrow distribution and desired morphology.
- **CLO 3:** Analyze the acquired knowledge and understanding of preparing the nanomaterials for various application.
- **CLO 4:** Analyze the acquired knowledge and understanding on effect of grain morphology and its needs for technological advancements.

UNIT-I BASICS IN MATERIALS PREPARATION & PHYSICAL ROUTES

Types of matter – Crystalline and Amorphous solids – Alloys – composites - compounds - Grain –Grain Growth-Grain boundary volume ratio –Temperature effects – Grain boundary segregation and pinning – Aggregation-Dimensional Classifications. High energy ball mill - Inert gas condensation Role of inert gases - Post oxidation process – Sputtering processes – Laser ablation - Pulsed laser deposition – Rapid solidification – Arc discharge method- photolysis – radiolysis - Fabrication of nanostructures and microfabrication using wet and dry etching-Lithography. **(15 Lectures)**

UNIT-II CHEMICAL AND BIOLOGICAL METHODS

Polyol route – Colloidal precipitation – Sol-Gel process– Chemical precipitation: Normal and Reverse reactions-Role of surfactant – Hydrolysis: Reaction kinetics – Hydrothermal – Solvothermal – Sonochemical – Template route: DC and Pulsed electrodeposition and Electroless deposition – Combustion route – Biological Methods: synthesis of nanomaterials using bacteria, fungi, yeast and Actinomycetes – magnetotactic bacteria for natural synthesis – role of plants in NPs synthesis and Phytoremediation. **(15 Lectures)**

UNIT-III SPECIALIZED TECHNIQUES

Electrophoretic deposition – Chemical Vapour deposition: Wet and Dry oxidation process – Dip and Spin coating process – Successive ionic layer adsorption and reaction (SILAR) – Spray and Flame spray pyrolysis – Self assembly. **(15 Lectures)**

UNIT-IV IMPORTANCE OF MORPHOLOGY

Crystallites With Various Morphologies – Polymorphs – Surface Aspect Ratio – Grain size distributions – Surface area – Current Status and Forecast for The Future Trends. **(15 Lectures)**

Text Books/Reference Books:

1. Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag (2004).
2. Vacuum Technology, A. Roth, North-Holland Pub., 2nd Edition (1982).
3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A. Muller, K. Cheetham (Eds), Wiley-VCH Verlag (2004).
4. B.S. Murty and S. Ranganathan, International Materials Reviews (1998) Vol. 43(3), 101.
5. Nanoparticles And Nanostructured Films Preparation, Characterization and Applications, Janos H. Fendler (Ed) Wiley (1998).
6. H. Gleiter, Progress in Materials Science, Vol.33, p.223 (1989).
7. NPTEL: Nanotechnology, Science and Applications https://nptel.ac.in/courses/113/106/113106093/.
8. YOUTUBE: Introduction to Nanomaterials https://www.youtube.com/watch?v=qUEbxTkPIWI.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	3	3	2	2	3	1	1	2.4
2	3	3	3	3	3	2	3	1	2	2	2.5
3	3	3	3	3	3	3	3	3	3	2	2.9
4	3	3	3	3	3	2	2	3	1	1	2.4
Average PLO	3	3	3	3	2.5	2.25	2.5	2.5	1.75	1.5	2.55

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	2.4
2	3	3	3	2	1	2.4
3	3	3	2	2	2	2.4
4	3	3	3	2	2	2.6
Average PSO	3	3	2.75	2	1.5	2.45

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E203	**Characterization Techniques of Nanomaterials - I**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Explore the properties of nanomaterials for the particular applications. Understand the principles of characterization techniques and study the properties of nanomaterials.
- **CLO 2:** Explain the instrumentation involved in the characterization technique
- **CLO 3:** Identify the suitability of the characterization for the particular material.
- **CLO 4:** Analyze the interpretation of the results obtained from the characterization techniques.

UNIT -I INTRODUCTION TO SPECTROSCOPY AND X-RAY TECHNIQUE

Basic principles and applications of UV-Vis-NIR, Fourier transform infrared spectroscopy, Photoluminescence, Nuclear magnetic resonance spectroscopy. X-ray powder diffraction –Quantitative determination of phases- single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis – particle size analysis using Scherer formula- Particle Size Analyzer. **(16 Lectures)**

UNIT-II ELECTRON SPECTROSCOPY

X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials – Electron energy loss spectroscopy (EELS)– Energy dispersive X-ray analysis (EDAX) and Swear debris analysis (WDA).

(15 Lectures)

UNIT-III MECHANICAL PROPERTIES MEASUREMENT

Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- Nanoindentation load- displacement curves - MD simulation of nanoindentation- Hardness testing of thin films and coatings. **(14 Lectures)**

UNIT-IV MAGNETIC AND ELECTRICAL PROPERTIES MEASUREMENT Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of nanomaterials. **(15 Lectures)**

Text Books / Reference Books:

1. Introduction to Spectroscopy *dl.iranchembook.ir* › ebook › organic-chemistry-2753.
2. An Introduction to Surface Analysis by XPS and AES | Wiley ... *onlinelibrary.wiley.com* › doi › book.
3. EPMA - electron probe microanalysis *www.ems.psu.edu* › harbin › EPMA.ppt.pdf.
4. Physical Property Measurement System www.mrl.ucsb.edu › instruments › hcapPPMS.
5. Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977.
6. Transmission Electron Microscopy: A Textbook for Materials Science, David B Williams, C Barry Carter, (1996) Plenum Press, New York.
7. Impedance Spectroscopy: Theory, Experiment, and Applications, E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley & Sons (P)Ltd.
8. Fundamentals of Fourier Transform Infrared Spectroscopy, Brian C Smith, (1995) CRC Press.
9. Nanoindentation, By Anthony C Fischercripps, Anthony C., Springer science and Bussiness media publications, 2011
10. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	3	3	2	2	3	1	1	**2.4**
2	3	3	3	3	3	2	3	1	2	2	**2.5**
3	3	3	3	3	3	3	3	3	3	2	**2.9**
4	3	3	3	3	3	2	2	3	1	1	**2.4**
Average PLO	**3**	**3**	**3**	**3**	**2.5**	**2.25**	**2.5**	**2.5**	**1.75**	**1.5**	**2.55**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	**2.4**
2	3	3	3	2	1	**2.4**
3	3	3	2	2	2	**2.4**
4	3	3	3	2	2	**2.6**
Average PSO	**3**	**3**	**2.75**	**2**	**1.5**	**2.45**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E204	**Nanomedicine and Drug Delivery**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Explain the basics of nanomedicine, surgical needs and imaging tools in medicine field. Understand the biopharmaceutical nanomaterials required for drug delivery.
- **CLO 2:** Explain the various types of sensors for medical analysis.
- **CLO 3:** Evaluate the properties of nanocarriers for diagnosis and therapeutic application.
- **CLO 4:** Summarize and analyze the application of nanocarriers in drug delivery.

UNIT – I PROSPECT OF NANOMEDICINE & TYPE OF SENSORS

History of the idea – The Biological and Mechanical Traditions–Nanomedicine- Taxonomy–Bio-Pharmaceuticals-Implantable Materials-Implantable Devices-Surgical Aids-Diagnostic Tools-Genetic Testing-Imaging. Chemical and Molecular Sensors- Displacement and Motion sensors-Force Nanosensors- Pressure sensing-Thermal nanosensors-Electric and Magnetic Sensing. **(15 Lectures)**

UNIT – II NANOCARRIERS

Needs and Requirements-Nanoparticle Flow: Implications for Drug Delivery-Genetic vaccines: A Role for Liposomes-Polymer Micelles as Drug Carriers-Recent advances in Microemulsions as Drug Delivery Vehicles. **(15 Lectures)**

UNIT – III NANOCAPSULES

Preparation, Characterization and Therapeutic Applications-Aerosols as Drug Carriers-Magnetic Nanoparticles as Drug Carriers – Nanomedicine for eye Ophthalmology. **(15 Lectures)**

UNIT – IV APPLICATIONS OF DRUG DELIVERY

Delivery of Nanoparticles to the Cardiovascular System-Nanocarriers for the vascular Delivery of Drugs to the Lungs-Nanoparticulate Carriers for Drug Delivery to the Brain- Pharmaceutical Nanocarriers in Treatment and Imaging of Inflection. **(15 Lectures)**

Text Books/Reference Books:

1. Nano Medicines Edited by Dr. Parag Diwan and Ashish Bharadwaj, Pentagon Press (2006) ISBN 81-8274-139-4.
2. Nanoparticulates as Drug Carriers, Edited by Vladimir P. Torchilin, Imperical College Press, North Eastern University, USA (2006) ISBN 1-86094-630-5.
3. https://link.springer.com/content/pdf/10.10090Fs11834-013-6063-0.pdf
4. http://nopr.niscair.res.in/bitstream/123456789/5224/1/IJEB2045(2)20160-65.pdf

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	3	3	2	2	3	1	1	**2.4**
2	3	3	3	3	3	2	3	1	2	2	**2.5**
3	3	3	3	3	3	3	3	3	3	2	**2.9**
4	3	3	3	3	3	2	2	3	1	1	**2.4**
Average PLO	**3**	**3**	**3**	**3**	**2.5**	**2.25**	**2.5**	**2.5**	**1.75**	**1.5**	**2.55**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	**2.4**
2	3	3	3	2	1	**2.4**
3	3	3	2	2	2	**2.4**
4	3	3	3	2	2	**2.6**
Average PSO	**3**	**3**	**2.75**	**2**	**1.5**	**2.45**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-C251	**Lab-II (Nanoscience Lab)**				**Laboratory**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
0	**0**	**4**	**4**	**100**	**120**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Acquire practical skills in the use of instruments, technologies and methods to fabricate nanomaterials and their characterization. Apply the practical knowledge in understanding the structural of the materials
- **CLO 2:** Provides opportunities to synthesize the materials using different approaches
- **CLO 3:** Master the technical skills in handling lab equipments, characterizing the acquired data and analyze using appropriate tool
- **CLO 4:** Understand the role of environmental conditions on the preparation of nanomaterials

List of Experiments -

1. Synthesis of Silver Nanoparticles by Chemical Reduction Method and their UV–Visible Absorption Studies.
2. Synthesis of Gold Nanoparticles by Chemical Reduction Method and their UV–Visible Absorption Studies.
3. Synthesis of Silver Nanoparticles by Polyol Method and their UV–Visible Absorption Studies.
4. Synthesis of Zinc Oxide (ZnO) Nanoparticles by Sol–Gel Method and Characterization using UV–Visible Spectroscopy.
5. Green Synthesis of Silver Nanoparticles Using Plant Extract and UV–Visible Characterization.
6. Biosynthesis of Silver Nanoparticles Using Bacteria and UV–Visible Characterization.
7. Study of Chemical Kinetics Using UV–Visible Spectroscopy and Band Gap Estimation Using Tauc Plot.
8. Synthesis of Titanium Dioxide (TiO_2) Nanoparticles by Sol–Gel Method and Characterization using XRD and SEM.
9. Synthesis of Cerium Oxide (CeO_2) Nanoparticles and Characterization using XRD and SEM.
10. X-ray Diffraction Studies of TiO_2 Nanoparticles and Determination of Crystallite Size Using Scherrer Equation.
11. Synthesis of Cerium Oxide (CeO_2) Nanoparticles by Co-precipitation Method.
12. Synthesis of Zinc Oxide (ZnO) Nanoparticles by Co-precipitation Method and UV–Visible Characterization.
13. Synthesis of Copper Oxide (CuO) Nanoparticles by Chemical Precipitation Method and UV–Visible Characterization.
14. Synthesis of Iron Oxide (Fe_3O_4) Magnetic Nanoparticles by Co-precipitation Method and Structural Characterization.
15. Determination of Optical Band Gap of Semiconductor Nanoparticles Using Tauc Plot.
16. Particle Size Distribution Analysis Using Dynamic Light Scattering (DLS).
17. FTIR Spectroscopic Analysis of Synthesized Nanoparticles.
18. Photocatalytic Degradation of Methylene Blue Using TiO_2/ZnO Nanoparticles.
19. Evaluation of Antibacterial Activity of Silver Nanoparticles by Agar Diffusion Method.
20. Comparative Study of Chemically Synthesized and Green Synthesized Silver Nanoparticles.
21. Measurement of Zeta Potential for Colloidal Stability of Nanoparticle Suspensions.

Note -

1. Students are required to perform any five experiments from the above list.
2. In practical examination the student shall be required to perform **one** experiment from the list.
3. Experiment shall carry **40 Marks** and **20 Marks** shall be assigned for viva-voce examination. **10** Marks shall be reserved for practical record.
4. No batch for practical class shall consist of more than **20** students.
5. The number of students in a batch allotted to an examiner for practical examination shall not exceed **12-15** students.
6. Addition/deletion in the above list of **some experiments of similar nature** may be made in accordance with the facilities available with the approval of **H.O.D**.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	2	1	2	2.2
2	3	3	3	3	3	2	3	1	2	2	2.5
3	3	3	3	3	3	3	3	2	3	2	2.8
4	3	3	3	3	2	2	2	2	1	1	2.2
Average PLO	3	3	3	2.75	2.5	2.25	2.5	1.75	1.75	1.75	2.42

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	2	2	1	2.2
2	3	3	2	2	1	2.2
3	3	3	2	2	2	2.4
4	3	3	3	2	2	2.6
Average PSO	3	3	2.25	2	1.5	2.35

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E205	**Nanobiotechnology**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- **CLO1**: Understand the basics of bioinspired strategies for the fabrication of Implants. analyze the importance of bioactive nanomaterials in bone grafting and tissue engineering.
- **CLO2**: Recognize the significance of Biomolecules in the fabrication of Nanostructures.
- **CLO3**: Study the applications of Polymer nanofibers in Tissue engineering and its merits and demerits.
- **CLO4:** Understand the overall basics of biomolecules and its application in Nano biotechnology.

UNIT-I

Bio-mineralized Inorganic Nanomaterials – Nanostructures and dynamics of Biocompatible surfactant monolayers and bilayers – Bio-interface, Bio- conjugation, Bio-matrix based on bioinspired phospholipids polymers. Self-assembly of ionic-complementary peptides and their applications in nano- biotechnology –from nanocluster assays to optical biochips for nano- biotechnology –bioactive nanomaterials in bone grafting and tissue engineering-inorganic /polymer nano composites for dental restoration and bone replacement applications. **(20 Lectures)**

UNIT-II

DNA based artificial nanostructures: fabrication, properties and applications – Nucleic acid engineered nanomaterials and their applications- RNA, DNA. **(10 Lectures)**

UNIT-III

Protein patterning for applications in biomaterials and biodevices. Polymers nanofibers and their applications in bioengineering – functional polymers for bone tissue engineering applications – applications of nanotechnology in tissue Engineering. **(15 Lectures)**

UNIT-IV

Vesicles and liposomes in sensor technology –Self-assembling nanostructured injectable polymeric gels for drug delivery - Engineering surface erodible polyanhydrides with tailored microstructure for controlled drug and protein delivery. **(15 Lectures)**

Text Book/Reference Books:

1. Challa S.S.R. Kumar (Ed) Biological and pharmaceutical nanomaterials: Wiley – VCH Verlag GmbH& Co, KgaA.
2. Ninmeyer C.M, Mirkin C.A (Eds) 2005. Nanobiotechnology.
3. H.S. Nalwa (Ed) Handbook of Nanostructured Bio materials and their applications in Nanobiotechnology, American Scientific Publishers, 2005.
4. http :// www.routledgehandbooks.com.
5. https://onlinelibrary.wiley.com.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	2	3	2	2	2	3	3	2	1	**2.3**
2	3	2	2	3	3	2	3	1	2	2	**2.3**
3	3	2	2	3	3	3	3	3	3	2	**2.7**
4	3	2	2	2	2	2	3	3	2	1	**1.9**
Average PLO	**3**	**2**	**2.25**	**2.5**	**2.5**	**2.25**	**3**	**2.5**	**2.25**	**1.5**	**2.3**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
3	3	2	2	2	2	**2.2**
4	3	2	3	2	2	**2.4**
Average PSO	**3**	**2**	**2.75**	**2**	**1.5**	**2.25**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E206	**Introduction to Nanotoxicology**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- **CLO1:** Understand the basic of Toxoicology and Nano science and differentiate between nanomaterials and bulk materials.
- **CLO2:** Evaluate and critically review the theoretical and practical aspects of Nanomaterials application. Critically assess and outline the nanoscience related to nanotoxicology.
- **CLO3:** Demonstrate the new properties of Nano materials and its significance in toxicology.
- **CLO4:** analyze the overall basics of nanotoxicology and its application in various field.

UNIT – I AREAS OF TOXICOLOGY

Introduction- definition of terms- areas of Toxicology- Toxicant- Types of Toxic hazardous materials- Physical Hazard, Chemical hazard, Biological Hazard, Toxic metabolites, Assessment of Risk- Risk assessment of Nanoparticles and Human Health. **(15 Lectures)**

UNIT – II NANOMATERIALS AND NANOPOLLUTION

Nanoparticles in the Environment- Nanomaterials in the atmosphere, Particle Characterization, Types of Transport, Routes of Exposure, Deposition mechanism, Potential mechanism of Nanosize particle toxicity, Passage through biological Membranes, toxic kinetics. Nanomaterials in environment, Source of pollution, Transport through environment. **(20 Lectures)**

UNIT – III NANOMATERIAL EXPOSURE MEASUREMENT

Nano sized materials exposure to human, Measurement methods, Threshold values-permissible limits. **(10 Lectures)**

UNIT IV - PORTALS OF NANOMATERIALS ENTRY

Types of portals entry, Target tissue, Routes of entry of nano pollutants, Absorption, Distribution mechanism on target tissue. **(15 Lectures)**

Text Books / Reference Books:

1. Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, *CRC Press, 2008.*
2. Nanotechnology: Environmental Health and Safety, Risks, Regulation and Management, Matthew Hull and Diana Bowman, Elsevier, 2010.
3. Principles and Methods of Toxicology. Edited by A.W. Hayes. Taylor and Francis, 2008.
4. https://www.intechopen.com/books/toxicology-new-aspects.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	1	1	**2.2**
2	3	2	2	3	3	2	3	3	2	2	**2.5**
3	3	2	2	3	3	2	3	3	3	2	**2.6**
4	3	2	2	2	2	2	2	3	1	1	**1.9**
Average PLO	**3**	**2.25**	**2.25**	**2.5**	**2.5**	**2**	**2.5**	**3**	**1.75**	**1.5**	**2.3**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	2	**2.6**
2	3	3	3	2	2	**2.6**
3	3	3	2	2	2	**2.4**
4	3	3	3	2	2	**2.6**
Average PSO	**3**	**3**	**2.75**	**2**	**2**	**2.55**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E207	**Research Methodology**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**30**

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- **CLO1:** Understand the aims and objectives research and formulate a research workplan in a scientific manner. Evaluate and critically review the theoretical and practical aspects of Research.
- **CLO2:** Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments. Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments. Obtain and evaluate information from a variety of databases and communicate effectively in a variety of forms like research publications, patents.

UNIT – I FOUNDATIONS OF RESEARCH & RESEARCH DESIGN

Meaning, Objectives, Motivation, Utility. Concept of theory, Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process, Research Question – Measurement Issues – Hypothesis – Qualities of a good, Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. Concept and Importance in Research – Features of a good research design concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. Qualitative and Quantitative Research: Qualitative research – Quantitative research – Merging the two approaches. Measurement: Concept of measurement– what is measured Problems in measurement in research – Validity and Reliability- Levels of measurement. **(15 Lectures)**

UNIT – II DATA ANALYSIS

Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample- Determining size of the sample – Practical considerations in sampling and sample size.

Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi- square test including testing hypothesis of association. Layout of a Research Paper, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Forms and types of scientific reports. Steps involved in scientific article writing. Publication process, selection of journals- Dissertation/Thesis writing: format, content and chapterization, Bibliography and references, referencing styles. Appendices. Reference Management -Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MSOffice, Software for detection of Plagiarism.

(15 Lectures)

Text Books/Reference Books:

1. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition.
2. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.
3. Research Methodology – C.R. Kothari, New Age International, New Delhi, 2014.
4. Kumar, R. Research Methodology–A Step-By-Step Guide for Beginners; 2nd Ed., Pearson Education: New Delhi, 2005.
5. Montgomery, D. C. Design & Analysis of Experiments; 8th Ed., Wiley India: Noida, 2013.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	2	2	1	2	2	2	2	3	1	1	**1.8**
2	2	2	1	3	3	2	3	1	2	2	**2.1**
Average PLO	**2**	**2**	**1**	**2.5**	**2.5**	**2**	**2.5**	**2**	**1.5**	**1.5**	**1.95**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	2	3	2	2	1	**2**
2	2	3	2	2	1	**2**
Average PSO	**2**	**2**	**2**	**2**	**1**	**2**

High – 3, Medium – 2, Low - 1

Semester III

Course Code	Course Title				Type of Course
MNN26-C301	**Nanoelectronics and Nanosensors**				**C**
L	T	P	Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Describe the principles of nanosensors.
- **CLO 2:** Analyze the different types of nanodevices for applications.
- **CLO 3:** Discuss about electronic and photonic materials.
- **CLO 4:** Describe about the basics of nanosensors. Relate the application of nanosensors.

UNIT-I BASIC CONCEPT OF NANOELECTRONICS

New Perspectives- New Ohm's Law- Density of states- Fermic Function- Types of Conductance- Ballastic Conductance- Resistance: Ballistic to Diffusive- Nano transistors. **(10 Lectures)**

UNIT-II SEMICONDUCTOR NANODEVICES

Nano Scale MOSFET – Single-Electron Transistors; Nanorobotics and Nanomanipulation; Molecular Nanowires- Organic LED, Organic FETs-CNT And Graphene FET, Si NW FET. **(15 Lectures)**

UNIT-III ELECTRONIC AND PHOTONIC MATERIALS

Single Electron Tunnelling Phenomena- Coulomb Blockad - RSD and Resonant Tunnelling Transistor- Quantum Structures Based LEDs - OLED and Photo Detectors- Magnetic Quantum Dots and their Applications. **(15 Lectures)**

UNIT-IV BASICS & TYPES OF NANOSENSORS

Micro and Nano - Sensors, Fundamentals of Sensors, Biosensor, MEMS And NEMS, Packaging and Characterization of Sensors, Method of Packaging at Zero Level, Dye Level and First Level, Temperature Sensors, Heat Sensors. Electromagnetic Sensors, Electrical Current Sensors, Electrical Voltage Sensors, Electrical Power Sensors, Magnetism Sensors - Mechanical Sensors -Pressure Sensors, Gas and Liquid Flow Sensors, Position Sensors - Chemical Sensors - Gas Sensor, Bio Sensors - DNA Based Biosensors. **(20 Lectures)**

Text Books/Reference Books:

1. Introduction To Molecular Electronics, M.C. Pettey.
2. The Physics and Chemistry of Nanosolids, Frank J. Owens and Charles P. Poole Jr., Wiley Interscience (2006).
3. Nanotechnology Enabled Sensors, Kouroush Kalantar–Zadeh, Benjamin, Fry, Springer (2007).

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	2	2	2	2	2	3	2	2	**2.3**
2	3	3	2	3	3	2	3	1	2	2	**2.4**
3	3	3	2	3	3	3	3	3	3	2	**2.8**
4	3	3	2	2	2	2	2	3	1	1	**2.1**
Average PLO	**3**	**3**	**2**	**2.5**	**2.5**	**2.25**	**2.5**	**2.5**	**2**	**1.75**	**2.4**

High – 3, Medium – 2, Low - 1

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	2	**2.6**
2	3	3	3	2	2	**2.6**
3	3	3	2	2	2	**2.4**
4	3	3	3	2	2	**2.6**
Average PSO	**3**	**2**	**2.75**	**2**	**2**	**2.55**

Course Code		Course Title			Type of Course
MNN26-C302		**Properties of Nanomaterials**			**C**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** analyze the electrical and magnetic properties of nanostructured materials. Describe various magnetic properties of materials.
- **CLO 2:** Analyze the optical properties of materials.
- **CLO 3:** Analyze the mechanical properties of materials.
- **CLO 4:** Analyze the thermal properties of materials.

UNIT I ELECTRICAL, DIELECTRIC & MAGNETIC PROPERTIES

Electrical: Temperature Coefficient of Resistance–Resistivity–Arrhenius Relation–Activation Energy; Dielectrics: Types of Polarization–Dielectric Constant–Dielectric Loss–Dielectric Breakdown–Double Schottky potential Barrier Height Model. Origin of Magnetism in material – Classification – Magnetic Moment – Magnetic Hysteresis – Magnetostriction – Curie Transition – Neel Temperature –Giant and Colossal Magnetoresistance– Super paramagnetism–Magnetic phenomena at Nanoscale. **(20 Lectures)**

UNIT II OPTICAL PROPERTIES

Optical phenomena in Materials–Surface Plasmon Resonance–Bandgap tailoring–Burstein – Moss Effect – Direct and Indirect Transitions – Effective Mass Approximation Theory – Kubelka – Munk function – isobestic effect – Hyper, Hypso, Batho and Hypochromic effects –Fluorescence: Stoke Shift. **(15 Lectures)**

UNIT III MECHANICAL PROPERTIES

Mechanical: Modes of deformation – Elastic and plastic deformation – Compressive strength-Mechanical stiffness–Fracture–Toughness–Superplasticity–Hardness–Micro- hardness–Fracture–Toughness –Indentation –Hall-petch Relation. **(15 Lectures)**

UNIT IV THERMAL PROPERTIES

Thermal: Thermal conductivity–Expansion–Stress–Specific Heat Capacity–Glass Transition Temperatures–Melting-point Depression. **(10 Lectures)**

Text Books / Reference Books:

1. Springer Handbook of Nanotechnology- Ed. by B. Bhushan, Springer-Verlag (2004).
2. Magnetic Materials: Fundamentals and Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018).
3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R. Rao, A. Muller, K. Cheetham (Eds), Wiley-VCH Verlag (2004)
4. Dan Guo *et al*, Journal of Physics D: Applied Physics (2018) Vol. 47, 013001.
5. Impedance Spectroscopy: Theory, Experiment, and Applications, E Barsoukov and JRoss MacdonaldWiley (2018).
6. H. Gleiter, Progress in Materials Science, Vol.33, p.223 (1989)
7. NPTEL: Defect Structure & Mechanical Behavior of Nanomaterials. https://www.youtube.com/watch?v=bwZW96c743A.
8. YOUTUBE: Introduction to Nanomaterials. https://www.youtube.com/watch?v=qUEbxTkPIWI.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	1	1	**2.2**
2	3	2	2	3	3	2	3	1	2	2	**2.2**
3	3	2	2	3	3	3	3	3	3	2	**2.7**
4	2	2	2	2	2	2	2	3	1	1	**1.9**
Average PLO	**2.75**	**2.25**	**2.25**	**2.5**	**2.5**	**2.25**	**2.5**	**2.5**	**1.75**	**1.5**	**2.25**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
3	3	2	2	2	2	**2.2**
4	3	2	3	2	2	**2.4**
Average PSO	**3**	**2**	**2.75**	**2**	**1.5**	**2.25**

High – 3, Medium – 2, Low - 1

Course Code		Course Title			Type of Course
MNN26-E303		**Nanotechnology for Food and Agriculture**			**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Define and identify functional materials for food industry.
- **CLO 2:** Understand and describe food and agricultural processes. Interpretation and application of the theories and protocols for soil and food nutrient management.
- **CLO 3:** Differentiate different types of nanomaterials food sensing, nutrient management and packaging application.
- **CLO 4:** Evaluation and assessment of various functional materials for sensing, nutrient management and packaging processes.

UNIT-I SENSORS FOR SOIL, SEED AND FOOD MONITORING

Introduction and Importance, Various Sensing Methods, Chemical and Biosensors, Sensors for Monitoring Soil, Seed and Food, Nanomaterials for Intelligent Sensors. **(15 Lectures)**

UNIT-II FUNCTIONAL MATERIALS AND NANOFERTILIZER

Functional Materials for Food and Agriculture Use - Super Absorbent Polymers, Coatings, Aerosols. Zeolites, Nano-Clays, Nano Emulsion, Nanofertilizer: Synthesis and Characterization. Fungicides, Herbicides – Pesticides. Types Of Nano-Formulations – Encapsulation of Pesticides. Release Studies, Smart Delivery, Bio- Efficacy and Bio-Safety. **(15 Lectures)**

UNIT-III MICRO-NANO ENCAPSULATION

Encapsulation – Principles – Micro and Nano-Encapsulation – Release Mechanism –Encapsulation Versus Traditional Delivery Method - Sorption and Release of Nutrients. Encapsulation Technologies – Extrusion –Spray Chilling – Spray Coating – Spray Drying – Emulsion – Gel Particles. **(15 Lectures)**

UNIT-IV NANOCOMPOSITES AND FOOD PACKAGING

Introduction And Scope. Polymer Films and Nano Composites – Bio-Nano Composites - Fabrication Process – Equipments Used - Testing Standards- Nano Material in Food Packaging - Solid and Liquid Food - Safety Issues of Nano Food Systems. **(15 Lectures)**

Text Books / Reference Books:

1. Nanotechnologies in Food and Agriculture, Mahendra Rai, Caue Ribeiro, Luiz Mattoso, Nelson Duran, Springer (2015).
2. Nanotechnology Applications in Food, Alexandru Grumezescu, Alexandra Oprea, Academic Press (2017).
3. Nano and Microencapsulation For Foods, Hae-Soo Kwak, Wiley (2018).

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	1	1	**2.2**
2	3	2	2	3	3	2	3	3	2	2	**2.5**
3	3	2	2	3	3	3	3	3	3	2	**2.7**
4	2	2	2	2	2	2	2	3	1	1	**1.9**
Average PLO	**2.75**	**2.25**	**2.25**	**2.5**	**2.5**	**2.25**	**2.5**	**3**	**1.75**	**1.5**	**2.32**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	**2.4**
2	3	3	3	2	1	**2.4**
3	3	3	2	2	2	**2.4**
4	3	3	3	2	2	**2.6**
Average PSO	**3**	**3**	**2.75**	**2**	**1.5**	**2.45**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E304	**Biomedical Nanotechnology**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Discuss the basic of Biomedical sciences and their usage in different fields.
- **CLO 2:** Evaluate and critically review the theoretical and practical aspects of Nano materials in biomedical application.
- **CLO 3:** Summarize the concepts in Biomedical nanomaterials in pharmacy.
- **CLO 4:** Critically assess and outline the nanotechnology for all areas of biomedical application. Demonstrate the new properties of Nano materials for next generation medical needs.

UNIT-I BIO CERAMICS FOR IMPLANT COATING

Calcium phosphate, hydroxy epilates Ti_6Al_4V, biomedical alloys - implant tissue interfacing – metal organic CVD – osteoporosis – osteoplastic – regeneration of bones by using bio compactable ceramics. **(10 Lectures)**

UNIT-II TISSUE ENGINEERING

Scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies – nano-featured and bioactive scaffolds – nano-fiber scaffolds – nanocomposite scaffolds – scaffolds for stem cells – micro and nanopatterned scaffolds - scaffolds and stem cells – fibrous proteins and tissue engineering. **(15 Lectures)**

UNIT-III DRUG DELIVERY

Diagnosis of diseases, treating and preventing of diseases – targeted for drug delivery – ligand coupled nanoparticle features – methods for coupling targeting ligands to nanoparticles – targeting modalities – barriers to tumor targeting *in vivo* – MRI contrast, enhancement – Gene delivery. **(15 Lectures)**

UNIT-IV NANOPHARMACY AND NANOMEDICINE

Bio interactive hydro gels – PEG coating and surface modifications –PEG hyrogels patterned on surfaces- Nanopharmacy- multi-targeted drugs – delivery of nucleic acids – interaction of organic molecules of the drug with pathological tissue. Formation of nucleic acid core particle – protective steric coating – surface exposed ligands targeting specific tissues –biocompatible core-shell nanoparticles for medicine – configuration of core – shell structure with different cores, shells and biomolecules-least toxicity- nanocapsules. **(20 Lectures)**

Text Books / Reference Books:

1. Robert. W. Kelsall, Ian. W. Hamley, Mark Geoghegan (Ed), Nano Scale Science and Technology, John Wiley and son, ltd., 2005.
2. H. Fujita (Ed), Micromachines as Tools for Nanotechnology, Springer, 2003.
3. Mick Wilson Kamali Kannangara Geooff Smith Michelle, Simmons Urkhard Raguse, Nano Technology, Overseas India private Ltd.,2005.
4. Gunter Schmid, Nano Particles, Jhon wiley and sons limited, 2004.
5. K.K. Jain, Nano Biotechnology, Horizions Biosciences, 2006.
6. Malsch, N.H., "Biomedical Nanotechnology", CRC Press. (2005).
7. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH. (2007).
8. Kumar, C. S. S. R., Hormes, J. and Leuschner C., "Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact", WILEY -VCH Verlag GmbH & Co (2005).
9. https://link.springer.com/content/pdf/10.10090Fs11834-013-6063- 0.pdf
10. http://nopr.niscair.res.in/bitstream/123456789/5224/1/IJEB2045(2)20160-165.pdf

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	1	1	2.2
2	3	2	2	3	3	2	3	3	2	2	2.5
3	3	2	2	3	3	3	3	3	3	2	2.7
4	2	2	2	2	2	2	2	3	1	1	1.9
Average PLO	2.75	2.25	2.25	2.5	2.5	2.25	2.5	3	1.75	1.5	2.32

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	2.4
2	3	3	3	2	1	2.4
3	3	3	2	2	2	2.4
4	3	3	3	2	2	2.6
Average PSO	3	3	2.75	2	1.5	2.45

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E305	**Basics of Pharmaceutical Sciences and Quality Audit**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45 L+15T)**

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- **CLO1**: To Understand the principles and types of pharmaceutics.
- **CLO2**: To know the concept of pharmacology.
- **CLO3**: To understand the fundamental aspects of pharmaceutical product development.
- **CLO4**: To understand the Quality audit.

UNIT-I INTRODUCTION TO PHARMACEUTICAL SCIENCES AND PHARMACOLOGY

Introduction about Pharameceutical -Principles and types of pharmaceutical dosage forms-solid, liquid, semi-solids, aerosols. Routes of drug administration. Overview, sources of drugs, routes of drug administration, Pharmacokinetics-absorption, distribution, metabolism and excretion, Pharmacodynamics, Adverse drug reactions, Drug interactions. **(20 Lectures)**

UNIT-II PHARMACEUTICAL PRODUCT DEVELOPMENT

Fundamental aspects, pharmaceutical excipients, biopharmaceutical considerations, Principles of solubilization, dissolution, partition coefficient, ionization and bioavailability. **(10 Lectures)**

UNIT – III KINETICS AND DRUG STABILITY

General concept of physical and chemical stability of pharmaceutical product, factors affecting drug stability, Degradation rate constant, Half-life determination and expiration dating, Introduction to ICH guidelines, Accelerated stability studies. **(15 Lectures)**

UNIT-IV QUALITY AUDIT

Quality audit, Standard Operating Procedure (SOP), International Conference Harmonization (ICH), ISO-9000, ISO14000, WHO specifications, USFDA guidelines and ICMR. **(15 Lectures)**

Text Books / Reference Books:

1. Sed mtiazhaider. (2011). Pharmaceutical Master Validation Plan: The Ultimate Guide to FDA
2. Ira R. Berry, Robert A Nash (2013), Pharmaceutical process validation, 3rd Rev Edition.
3. Marcel Dekker, Quality Assurance of Aseptic Preparation Services: Standards Part A | Fifth edition, Alison M Beaney, Royal Pharmaceutical Society and the NHS Pharmaceutical Quality Assurance Committee,2016.
4. Manging for quality and performance excellence ninth edition James R.Every, William M.Lindsay South-western Cengage learning 2014.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	2	2	2	2	2	2	3	1	1	**2**
2	3	2	2	3	3	2	2	1	2	2	**2.2**
3	3	2	2	3	3	2	2	3	3	2	**2.7**
4	2	2	2	2	2	2	2	3	1	1	**1.9**
Average PLO	**2.75**	**2**	**2**	**2.5**	**2.5**	**2**	**2**	**2.5**	**1.75**	**1.5**	**2.2**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	2	2	2	2	1	**1.8**
2	3	1	2	2	1	**1.8**
3	3	2	2	2	2	**2.2**
4	3	1	3	2	2	**2.4**
Average PSO	**3**	**2**	**2.75**	**2**	**1.5**	**1.95**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E306	**Industrial Nanotechnology**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
3	**1**	**0**	**4**	**100**	**60 (45L+15T)**

Course Learning Objectives (CLOs): Upon successful completion of this course, students will be able to:

- **CLO1:** Development of new combination of nanomaterial based on their properties for future needs.
- **CLO2:** Evaluation and critical assessment of nanomaterials for various industrial application.
- **CLO3:** Assess the role of nanomaterial for enhancing the application effect. Review the industrial development and relevant nanomaterials supply with required functionalities.
- **CLO4:** Demonstrate the new properties of nanomaterials for next generation needs.

UNIT- I SEMICONDUCTOR NANOSTRUCTURES AND DEVICES

Fabrication and Applications of different types of semiconductor Nanostructures- Silicon horizontal and vertical core shell Nanowires- Integrated circuits- Sensors- Electro optical devices. Semiconductor Quantum dots (QDs) – QD LASER- Quantum cascade LASER devices. **(15 Lectures)**

UNIT- II NANOSCALE MAGNETIC MATERIALS

Application In Magnetic Storage Devices - Storing and Reading Device– Current Trends of Spin Based Electronic Devices. Optical Storage Devices: Near Field Optical Recording- Holographic Data Storage- AFM Based Recording Technology. **(10 Lectures)**

UNIT-III NANO ELECTRO MECHANICAL SYSTEMS AND NANOSTRUCTURING

Overview- Nano-Electromechanical Systems - Fabrication Process- Choice of Materials, Performance of Different Structures - Advantages and Disadvantages of Different Approaches. Applications In Sensors, Micro Actuators - Extension to The Nanoscale. Lithography-photo lithography-Phase shifting Photo Lithography- Electron beam Lithography— X-Ray Lithography- Focussed Ion Beam Lithography (FIB)- Neutron Atomic beam Lithography- Nanomanipulation-Micro fabrication. **(20 Lectures)**

UNIT-IV INDUSTRIAL APPLICATIONS OF NANOMATERIALS

Nanoparticles And Micro Organism for industrial application, Nano-Materials in Bone Substitutes and Dentistry, Food and Cosmetic Applications. Textiles, Paints, Catalysis, Drug Delivery and Its Applications, Biochips -Analytical Devices, Biosensors. **(15 Lectures)**

Text Books / Reference Books:

1. Nano Electronics, Parag Diwan and Ashish Bharadwaj, Pentagen Press (2006).
2. Principles of Superconductive Devices Aad Circuits, C.W. Turner and T. Van Duzer (1981).
3. Principles of Optical Electronics, A. Yariv, Wiley (1984).

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	1	1	**2.2**
2	3	2	2	3	3	2	3	1	2	2	**2.2**
3	3	2	2	3	3	3	3	3	3	2	**2.7**
4	2	2	2	2	2	2	2	3	1	1	**1.9**
Average PLO	**2.75**	**2.25**	**2.25**	**2.5**	**2.5**	**2.25**	**2.5**	**2.5**	**1.75**	**1.5**	**2.25**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
3	3	2	2	2	2	**2.2**
4	3	2	3	2	2	**2.4**
Average PSO	**3**	**2**	**2.75**	**2**	**1.5**	**2.25**

High – 3, Medium – 2, Low - 1

Course Code	Course Title			Type of Course
MNN26-E307	**Characterization Techniques of Nanomaterials - II**			**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**30**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** Describe the purpose of characterization for the given materials CO2. Explore the properties of nanomaterials for the particular applications
- **CLO 2:** Understand the instrumentation involved in the characterization technique. Understand the suitability of the characterization for the particular material. Relate the interpretation of the results obtained from the characterization

UNIT I MORPHOLOGICAL STUDIES AND MATERIAL DEFECTS STUDY

Principles, Overview of Instrumentation and Sample preparation, Experimental techniques adopted in: Scanning Electron Microscopy: SEM -Transmission Electron Microscopy (TEM) – HRTEM- Nanomanipulator-Nanotweezers. Scanning Tunnelling Microscopy (STM), Atomic Force MicroscopyAFM)-Non-contact-contact-Tapping- conducting mode-. Near Field Scanning Optical Microscopy; Scanning capacitance Microscopy- Magnetic Force Microscopes MFM)- Chemical Force Microscope (CFM). **(15 Lectures)**

UNIT – II THERMAL, MICROSCOPIC CHARACTERIZATION

Optical microscopes- Use of polarized light microscopy – Phase contrast microscopy – Interference Microscopy – hot stage microscopy - surface morphology – Etch pit density and hardness measurements- Confocal Microsocopes. Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures. New Advances and challenges in biological and biomedical materials characterizations- Dynamic light scattering spectroscopy. Confocal Microscopes - Confocal Raman – Application in Nanobiotechnology. Fluorescence Microscope. **(15 Lectures)**

Text Books/Reference Books:

1. Nanotechnology: basic science and emerging technologies-Mick Ailson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).
2. Nanocomposite science and technology, Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, Wiley-VCH Verlag, Weiheim (2003).
3. 'Advanced X-ray Techniques in Research and Industries' by A.K. Singh (ed.)
4. 'Transmission Electron Microscopy of Materials' by G. Thomas.
5. Physical Principles of Microscopy: An introduction to TEM, SEM and AFM by R.F. Egerton.
6. 'Instrumental Methods of Analysis (7^{th}edn.)' by Willard, Merritt, dean and Settle.
7. Scanning Electron Microscopy and X-ray Microanalysis' by J. Goldstein.
8. S.L. Flegler, J.W. Heckman and K.L. Klomparens, "Scanning and Transmission Electron Microscopy: An Introduction", WH Freeman & Co, 1993.
9. P.J. Goodhew, J. Humphreys, R. Beanland, "Electron Microscopy and Analysis",
10. R. Haynes, D.P. Woodruff and T.A. Talchar, "Optical Microscopy of Materials", Cambridge University press, 1986.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	3	3	2	2	3	1	1	**2.4**
2	3	3	3	3	3	2	3	1	2	2	**2.5**
Average PLO	**3**	**3**	**3**	**3**	**3**	**2**	**2.5**	**2**	**1.5**	**1.5**	**2.45**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	**2.4**
2	3	3	3	2	1	**2.4**
Average PSO	**3**	**3**	**3**	**2**	**1**	**2.4**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E308	**Advanced Nanomaterials for Nanotechnology**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**30**

Course Learning Objectives (CLOs):

- **CLO 1:** Understand the properties of nanostructured magnetism. Development of knowledge about magnetosomes.
- **CLO2:** Learn about working and types of biosensors. Applications of various nanomaterials in medical field. Demonstrate the pharmaceutically important nanomaterials as therapeutic agents.

UNIT – I NANOSTRUCTURED MAGNETISM, THERMOELECTRIC, POLYMERIC NANOMATERIALS

Nanostructure magnetism, Effect Bulk nanostructuring of magnetic property, Giant and colossal magnetic resistance, Nanomagnetic materials, Paramagnetism in metallic nanoparticles. Concept of phonon, Thermal conductivity specific heat, exothermic and endothermic processes, Different types of thermoelectric materials, One dimensional and composite thermoelectric materials and Applications. stress-strain behavior of polymer nanomaterials, glass transition temperature and relationship between Tm and Tg. Effect of molecular weight, property requirements and its utilization. Synthetic procedure for commercial polymers, Fire retarding and biomedical polymers. **(15 Lectures)**

UNIT – II NANOCOMPOSITES AND BIOPHOTONICS

Definition of nanocomposites - Types of nanocomposites – Synthesis of nanocomposites: Direct mixing, solution mixing, In-situ polymerization - Polymer/ Metal oxide nanocomposites, diblock copolymer based nanocomposites, Polymer/CNTs and Polymer/Nanoclay based composites. The interface of bioscience, nanotechnology and photonics - Semiconductor quantum dots for bioimaging – Metallic nanoparticles and nanorods for Biosensing - Inorganic nanoparticles – Pebble nanosensors for Invitro Bioanalysis - Nanoclinics for optical diagnostics and Targeted therapy. **(15 Lectures)**

Text Books/Reference Books:

1. Pradeep Fulay, Electronic, Magnetic and Optical Materials, CRC Press, Boca Raton (2010).
2. William S. Wong, Alberto Salleo, "Flexible Electronics: Materials and Applications",1st Edition, Springer, New York (2011).
3. Edward Sazonov, Michael R. Newman, "Wearable Sensors: Fundamentals, Implementation and Applications", 1st Edition, Academic Press, Cambridge (2014).
4. Rainer Waser, "Nanoelectronics and Information Technology Advanced Electronic Materials and Novel Devices", WILEY-VCH Verlag GmbH & Co. Weinheim, Germany (2003).
5. Gregory P. Crawford, "Flexible Flat Panel Displays", John Wiley & Sons Ltd., England (2005).
6. Yury Gogotsi, "Carbon Nanomaterials", CRC Press, Taylor & Francis group, Boca Raton,London, New York (2006).

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	3	2	2	2	3	1	1	**2.3**
2	3	2	2	3	3	2	3	1	2	2	**2.3**
Average PLO	**3**	**2.5**	**2.5**	**3**	**2.5**	**2**	**2.5**	**2**	**1.5**	**1.5**	**2.3**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
Average PSO	**3**	**2**	**3**	**2**	**1**	**2.2**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E351	**Lab-III (Nanoscience Lab)**				**Laboratory**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
0	**0**		**2**	**50**	**60**

Course Learning Objectives (CLOs): By the end of this course, students will be able to:

- **CLO 1:** To synthesis nanomaterials by different methods. To synthesis thin films using different techniques
- **CLO 2:** To synthesis various nanocomposites
- **CLO 3:** To characterize structurally the nanoparticles prepared and analysis their size and lattice parameters
- **CLO 4:** To characterize the nanomaterials prepared electrically and optically

List A – Synthesis of Nanostructured Materials

1. Preparation of Nanoparticles by Sol–Gel Method.
2. Synthesis of Nanoparticles by Co-precipitation Method.
3. Preparation of Nanostructured Thin Films by Dip Coating Technique.
4. Synthesis of Nanoparticles Using a Domestic Microwave Oven.
5. Preparation of Nanocomposites by Solvothermal Method.
6. Surface-Enhanced Raman Scattering (SERS) Studies of Gold and Silver Nanoparticles.
7. Synthesis of Quantum Dots and Photoluminescence Studies.
8. Green Synthesis of Silver Nanoparticles Using Plant Extract.
9. Hydrothermal Synthesis of ZnO Nanorods.
10. Chemical Reduction Synthesis of Gold Nanoparticles.
11. Synthesis of Magnetic Fe_3O_4 Nanoparticles by Co-precipitation Method.
12. Preparation of Core–Shell Nanostructures (e.g., SiO_2@Ag or Fe_3O_4@SiO_2).

List B – Characterization of Nanomaterials

1. X-ray Powder Diffraction Analysis and Determination of Lattice Parameters of Nanoparticles.
2. Impedance Measurement and Analysis Using Cole–Cole Plot.
3. Measurement of Dielectric Constant at Different Temperatures and Frequencies.
4. Determination of Optical Band Gap of Metal Oxide Semiconductors Using UV–Visible Spectroscopy.
5. Measurement of DC Electrical Conductivity of Nanoparticles at Different Temperatures.
6. Characterization of Carbon Dots Using UV–Visible Spectroscopy.
7. FTIR Spectroscopic Analysis of Nanomaterials.
8. Particle Size Analysis Using Dynamic Light Scattering (DLS).
9. Measurement of Zeta Potential for Colloidal Stability Analysis.
10. Raman Spectroscopic Characterization of Carbon-Based Nanomaterials.
11. Photocatalytic Degradation of Methylene Blue/Rhodamine B Using Semiconductor Nanoparticles.
12. Estimation of Crystallite Size, Microstrain, and Dislocation Density from XRD Data Using Scherrer and williamson–Hall Methods.

1. Students are required to perform any five experiments from the above list.
2. In practical examination the student shall be required to perform **one** experiment from the list.
3. Experiment shall carry **20 Marks** and **10 Marks** shall be assigned for viva-voce examination. **5** Marks shall be reserved for practical record.
4. No batch for practical class shall consist of more than **20** students.
5. The number of students in a batch allotted to an examiner for practical examination shall not exceed **12-15** students.
6. Addition/deletion in the above list of **some experiments of similar nature** may be made in accordance with the facilities available with the approval of **H.O.D**.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	2	1	2	**2.2**
2	3	3	3	3	3	2	3	1	2	2	**2.5**
Average PLO	**3**	**3**	**3**	**2.5**	**2.5**	**2**	**2.5**	**1.5**	**1.5**	**2**	**2.35**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	2	2	1	**2.2**
2	3	3	2	2	1	**2.2**
Average PSO	**3**	**3**	**2**	**2**	**1**	**2.2**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E309	**Biomaterials and Nanobiotechnology for Tissue Engineering**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**30**

Course Learning Objectives (CLOs):

- **CLO 1:** Understand the basic of Biology and Nano science and differentiate between nanomaterials and bulk materials. Evaluate and critically review the theoretical and practical aspects of Nano materials application. Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano biotechnology.
- **CLO2:** Critically assess and outline the nanotechnology for all areas of application. Understand the basics of tissue engineering and its application in vital organs and mode of bladder implant failure.

UNIT – I MATERIALS FOR IMPLANT

Orthopedic implants – material s used – modes of failure – wear debris stress and strain imbalances at the tissue implant interface. Dental: Dental materials used – modes of dental implant failure – debris, stress and strain imbalances at the tissue implant interface. Cartilage materials used – modes of cartilage implant failure –wear debris, stress and strain imbalances at the tissue implant interface; Vascular materials used – modes of vascular implant failure – wear debris; stress and strain imbalances at the tissue implant interface**.** Bladder overall view, Bladder implant materials used – modes of bladder implant failure – stress and strain imbalances at the tissue implant interface. **(15 Lectures)**

UNIT – II BIOLOGICAL EFFECT AND ADVANTAGE OF NANOMATERIALS

Biological response of Nanomaterials used as implants – biological response of implanted materials – desirable and undesirable reactions of the body with implanted materials: Protein interactions with implanted Materials. Advantages of Nanomaterials used as implants - cellular recognition of Proteins Adsorbed on material surfaces – adhesion – migration differentiation – Cellular Extra cellular Matrix deposition leading to tissue regeneration – foreign-body response – inflammatory response. **(15 Lectures)**

Text Books/Reference Books:

1. William A. Goddard, Sergey Edward Lyshevski, Donald W. Brenner (Ed) Handbook of Nanoscience, Engineering and Technology CRC press 2003.
2. Joachim Schummer, Davis Baird (Ed) Nanotechnology Challenges: implications for philosophy, Ethics and society; World scientific; 2006.
3. William Sims Bainbridge, Mihail C. Roco (Ed) Societal implication of Nanosciences and Nanotechnology; Springer; 2001.
4. Jon J. Kellar (Ed) Functional fillers and nanoscale minerals; new markets/ new horizons SME science; 2006.

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	2	2	2	2	3	1	1	**2.2**
2	3	2	2	3	3	2	3	3	2	2	**2.5**
Average PLO	**3**	**2.5**	**2.5**	**2.5**	**2.5**	**2**	**2.5**	**3**	**1.5**	**1.5**	**2.35**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	3	3	2	1	**2.4**
2	3	3	3	2	1	**2.4**
Average PSO	**3**	**3**	**3**	**2**	**1**	**2.4**

High – 3, Medium – 2, Low - 1

Course Code	Course Title				Type of Course
MNN26-E310	**Green Manufacturing Technology**				**E**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
2	**0**	**0**	**2**	**50**	**30**

Course Learning Objectives (CLOs):

- **CLO 1:** Identify waste and pollutants. Recognize the opportunities to improve efficiency.
- **CLO2**: Understand life cycle impacts and Conserve resources. CO4: Prevent pollution and improve the quality level. Keep a direct control on the quality of the formulation and assuring the compliance of standards.

UNIT – I SUSTAINABLE GREEN MANUFACTURING

Green Manufacturing: Fundamentals and Applications - basic definitions and issues surrounding green manufacturing at the process, machine and system - government motivations for green manufacturing – traditional manufacturing to green manufacturing -economic issues. Green Manufacturing processes, requirements and risk, International green manufacturing standards and compliance, Green rapid prototyping and rapid manufacturing, Green flexible automation, Green Collaboration Processes. Sustainable Green Manufacturing System. **(15 Lectures)**

UNIT – II NANOCOMPOSITES, WASTE MANAGEMENT AND INDUSTRIAL ECOLOGY

Sustainability and global conditions, Materials and Solid waste Management, Energy Management, Chemical Waste Management, and green chemistry, Water pollutants and their effects. Measurement of DO, BOD, COD and Pesticides as water Pollutants. Water supply and Waste-water Management.

Material flow in Chemical Manufacturing, Industrial Parks, Assessing opportunities for waste exchanges and by-product synergies, Regulatory, social and business environment for green manufacturing. Green Supply chains. Present state of green Manufacturing. Introduction to commercial plastics and elastomers, Natural Rubber, Modified Natural rubber and bends. Plastics from Vegetable oils, cellulose and starch- based materials. Nanocomposites: Natural fillers, Fibers and clay nanocomposites, biodegradability, life cycle assessment of using natural Materials.

(15 Lectures)

Text Books/Reference Books:

1. T. David Allen and David R. Shonnard, Green engineering, Prentice Hall NJ, (2002).
2. David Dornfeld, Green manufacturing fundamental and applications, Prentice hall (2002).
3. G. Sammy Shinga, Green electronics design and manufacturing, Prince publications (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. E. S. Stevens, Green plastics, Princeton university press (2002).

CLO-PLO Matrix for the Course:

Unit wise CLOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Average CLO
1	3	3	3	3	2	2	2	3	1	1	**2.3**
2	3	2	2	3	3	2	3	1	2	2	**2.3**
Average PLO	**3**	**2.5**	**2.5**	**3**	**2.5**	**2**	**2.5**	**2**	**1.5**	**1.5**	**2.3**

CLO-PSO Matrix for the Course:

Unit wise CLO	PSO1	PSO2	PSO3	PSO4	PSO5	Average PSO
1	3	2	3	2	1	**2.2**
2	3	2	3	2	1	**2.2**
Average PSO	**3**	**2**	**3**	**2**	**1**	**2.2**

High – 3, Medium – 2, Low - 1

Semester IV (Research)

Course Code	Course Title				Type of Course
MNN26-D471	**Dissertation/Internship**				**D**
L	T	P	Total Credits	Max. Marks	Total Contact Hrs.
0	**0**	**20**	**20**	**500**	**720**

Course Learning Outcomes (CLOs): After successfully completing this course, students will be able to:

- **CLO1 (Formulate and Plan Research):** Identify an original research problem in physics, conduct a critical literature review, and develop a clear proposal with well-defined objectives and methodology.
- **CLO2 (Design and Apply Research Methodology):** Select and justify suitable experimental, theoretical, or computational approaches, ensuring rigor and reproducibility.
- **CLO3 (Execute Research Independently):** Carry out the planned research, operating relevant instruments, software, or analytical techniques while demonstrating initiative and autonomy.
- **CLO4 (Collect, Analyze, and Interpret Data**): Acquire and process data systematically, apply appropriate statistical and computational tools, and critically evaluate findings against theoretical expectations.
- **CLO5 (Develop Problem-Solving and Critical Thinking Skills):** Identify challenges, assess limitations, and propose evidence-based solutions or future research directions.
- **CLO6 (Communicate Scientific Work Effectively** – Prepare a well-structured dissertation with high academic writing standards, proper citations, and clear data presentation; confidently present and defend findings in oral examinations.
- **CLO7 (Exhibit Professionalism and Ethical Research Practices):** Demonstrate integrity, time management, responsible conduct of research, and effective collaboration with mentors and peers.
- **CLO8 (Discuss Broader Impacts of Research):** Articulate the significance of research outcomes for scientific advancement, industry applications, or addressing societal challenges.

CLO-PLO Matrix for the Course:

Unit Wise CLOs	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	Average CLO
1	3	2	3	3	3	2	3	2.71
2	2	3	3	3	2	3	3	2.71
3	2	3	3	2	3	3	3	2.71
4	2	3	3	3	2	3	3	2.71
5	2	2	3	3	2	2	3	2.43
6	2	2	3	3	2	2	3	2.43
7	2	2	2	2	3	2	3	2.29
8	2	2	2	3	3	2	3	2.43
Average PLO	**2.125**	**2**	**2**	**3**	**3**	**2**	**3**	**2.55**

EVALUATION OF DISSERTATION WITH COURSEWORK AND RESEARCH:

(i) The Research (Dissertation/Project/Patent) in IVth Semester of PG Programme with coursework + Research carries 20 Credits which will carry 500 marks.

(ii) There will be only ESA for research (Dissertation/Project/Patent) in IVth semester for the structure with Coursework + Research. The research (Dissertation/project/patent) will be jointly evaluated by Internal Examiner and One External Examiner appointed by the Controller of Examinations. The obtained marks by the student will be forwarded by Head of the Department to the Controller of Examinations.

(iii) The Distribution of marks will be as follows for this component:

Dissertation/Project/Patent Report	**Presentation & Viva-Voce**	**Total Marks**
300 Marks (60% ESA)	200 Marks (40% ESA)	**500**