M.Sc.,
NANO SCIENCE AND NANO TECHNOLOGY

MODEL SYLLABUS

AUGUST : 2022

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,
CHENNAI – 600 005

LEARNING OUTCOMES – BASED CURRICULUM FRAME WORK GUIDELINES BASED REGULATIONS FOR POST GRADUATE PROGRAMME	
Programme:	**M.Sc. Nano-science and Nanotechnology**
Programme Code	
Duration	**2 years [PG]**
Program Outcomes (PO)	
On successful completion of the **M.Sc., Nano-science and Nanotechnology** program, the students are expected to	
PO1	Broad based knowledge in Industrial Biotechnology
PO2	Transforming meaningful applications for better healthcare, industries and economic development
PO3	Constant updation of knowledge
PO4	Empowering skills
PO5	Sole responsibility of contributing the public to lead better life through extension activities
PO6	Development of critical thinking and problem-solving skills
PO7	The provision of an inspiring, exciting and collaborative scientific environment
PO8	To inculcate the values of professionalism and dedication
PO9	Develop intelligent strategies and biochemical approaches in problem solving methods
PO10	To compete globally with confidence in all the sectors of life science

Program Specific Outcomes (PSO)	
On successful completion of the **M.Sc., Nano-science and Nanotechnology** program, the students are expected to	
PSO1	Ability to understand the technical aspects of modern nano level technologies that help in addressing the biological and medical challenges faced by humankind.
PSO2	Ability to contribute effectively in the development of the ethical practices, societal contributions, and leading to responsible and competent professionals
PSO3	Acquiring the ability of leadership skills to manage projects in multidisciplinary Environments
PSO4	Nurture problem solving skills, thinking, creativity through assignments, field work, seminar presentations and project work.
PSO5	Assist students in preparing (personal guidance, research papers, and books) for competitive exams e.g.,NET-JRF, SLET, etc.

M.Sc. NANO-SCIENCE AND NANOTECHNOLOGY

The preamble of the syllabus

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 to name a few.

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 Biotechnology. 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**.**

Examination Pattern:
Time allotted: Theory – 03Hrs. & Practical – 04 hrs

Marks allotted for university examination:

	External Marks	**Internal Marks**	**Total marks**
Theory	75	25	100
Practical	75	25	100

Marks distribution for internals:

	Test	**seminars**	**Assignment**	**Total marks**
Theory	15	05	05	25

	Test	**Record**	**Total marks**
Practical	10	15	25

Pattern of question paper (theory):

The course of study and the scheme of Examination – Department of Biotechnology

	Study Components		*ins. hrs / week*	*Credit*	*Title of the Paper*	*Maximum Marks*		
	Course Title					*CIA*	*Uni. Exam*	*Total*
SEMESTER I								
	Core	Paper -1	5	4	Introductory Physics	25	75	100
	Core	Paper -2	5	4	Introductory Chemistry	25	75	100
	Core	Paper -3	5	4	Introductory Biology	25	75	100
Internal Elective for same major students (Choose any one)								
	Core Elective	Elective – I	3	3	Introduction to Material Science	25	75	100
	Practical -I		10	4	Nanoscience Practical	25	75	100
	Value Added course	VAC-1	2	2	Laboratory Safety and Health Intellectural Property Rights. Innovation and Entrepreneurship	25	75	100
			30	**21**				
SEMESTER II						*CIA*	*Uni. Exam*	*Total*
	Core	Paper – 4	4	4	**Core Courses** Introduction to Nanoscience and Nanotechnology	25	75	100
	Core	Paper – 5	4	4	Preparation of Nanomaterials	25	75	100
	Core	Paper – 6	4	4	Characterization Techniques of Nanomaterials –I	25	75	100
	Core	Paper - 7	4	4	Nanobiotechnology	25	75	100
Internal Elective for same major students (Choose any one)								
	Core Elective	Elective -II	2	2	Introduction to Nanotoxicology	25	75	100
	Practical -II		8	4	Nanoscience Practical – II	25	75	100
						25	75	100
			30	**26**				

Study Components		*ins. hrs / week*	*Credit*	*Title of the Paper*	*Maximum Marks*		
Course Title					*CIA*	*Uni. Exam*	*Total*
SEMESTER III							
Core	Paper -9	4	4	**Core Courses** Nanoelectronics and Nano sensors	25	75	100
Core	Paper –10	4	4	Properties of Nanomaterials	25	75	100
Core	Paper – 11	4	4	Characterization Techniques of Nanomaterials-II	25	75	100

Core	Paper -18	4	4	Advanced Nanobiotechnology	25	75	100
Internal Elective for same major students (Choose any one)							
Core Elective	Elective -III	3	3	Biomaterials & Nanobiotechnology for Tissue Engineering	25	75	100
External Elective for other major students (Inter/multi-disciplinary papers) (Choose any one)							
Open Elective	Open Elective -II	2	2	Core Industry module-Industrial Nanotechnology	25	75	100
Practical - III		9	4	Nanoscience Practical – III	25	75	100
		30	**29**				
***MOOC Courses**			2				100
***USRR**			2				100
SEMESTER IV					***CIA***	***Uni. Exam***	***Total***
Core	Paper -13	4	4	Biomedical Nanotechnology	25	75	100
Core Elective	Elective -IV	3	3	Nanotechnology for Food and Agriculture	25	75	100
Core	**Project Compulsory**	**23**	8		100 (75 Project +25 viva)		100
		30	**15**				
		120	**91**		**725**	**2275**	**2900**

E**xtra credits for * MOOC course = 2**
*** USSR Project = 2**

SEMESTER I

CORE I

Course Code	**Course Name: INTRODUCTORY PHYSICS**		**Credits 4**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category: Core I	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of physics.		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of electromagnetic waves, current, magnetism,electronics and quantum mechanics. To gain knowledge on electronic devices such as diodes and transistors also quantummechanics		

CLO1	To understand fundamental concepts of physics which are necessary for nanoscience and technology subject
CLO2	To apply the gained subject knowledge to understand the nano-enabled devices in second and third semesters
CLO3	To evaluate microscopic scales with macroscopic Impact with the help of Physics.
CLO4	To understanding on real time applications of physics
CLO5	To analyze the acquired knowledge and understanding on real time applications of physics
Recap:	2 Tutorial hours
Contents and Required hours : (Total =90 hours)	

~~**Unit:1**~~	~~**18 hours**~~
~~**Unit:2**~~	~~**18 hours**~~
~~**Unit:3**~~	~~**18 hours**~~
~~**Unit:4**~~	~~**18 hours**~~
~~**Unit V**~~	~~**18 hours**~~

Unit:1	**WAVES AND OPTICS**	**18 hours**
Electromagnetic waves and their characteristics – Theories of light –Wave, Electromagneticand Quantum – Scattering of light: Rayleigh's and Tyndal scattering – Huygen's principle – Interference – Diffraction – Polarization of light waves		

Unit:2	ELECTRIC CURRENT	18 hours
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.		

Formatted Table

Unit:3	MAGNETISM	18 hours
Fundamental Concepts of Magnetism– Bohr Magtron- Magnetic Dipoles- Field- Electron Spin and Magnetic Moment- Magnetic moment due to Nuclear Spin- Magnetic dipoles- Permeability- Magnetization- Intensity of Magnetization – Magnetic Materials		
Unit:4	**ELECTRONICS**	**18 hours**
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		
Unit:5	**QUANTUM MECHANICS**	**18 hours**
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.		
Unit:6	**CONTEMPORARY ISSUES**	**2 hours**
Expert lectures, online seminars – webinars		
	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)	
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)
Reference Book(s)	
1.	Text Book Of Electronics, S. Chattopadhyay, New Central Book Agency pvt. Ltd., (2006).
2.	Magnetic Materials : Fundamentals And Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	NPTEL: Electromagnetism https://nptel.ac.in/courses/115/106/115106122/
2	NPTEL: Magnetic Properties https://www.youtube.com/watch?v=QQZ6EGf0Ju8
3	NPTEL: Quantum Mechanics https://nptel.ac.in/courses/115/101/115101107/

Formatted Table
Formatted Table
Formatted Table
Formatted Table
Formatted Table

Mapping with Programme Outcomes

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER I , CORE-II

Course Code	**Course Name: INTRODUCTORY CHEMISTRY**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Chemistry		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of electromagnetic waves, current, magnetism,electronics and quantum mechanics. To gain knowledge on electronic devices such as diodes and transistors also quantummechanics		

CLO1	Define and identify differential branches of chemistry and theirimportance
CLO2	Understand and describe chemical concepts and processes
CLO3	Interpretation and application of the theories to chemical process andderivations.
CLO4	Differentiate different properties and mechanisms of organic reactions,inorganic properties and physical concepts
CLO5	Evaluation and assessment of the theories and chemical process fordifferent applications.
Recap:	2 Tutorial hours
Contents and Required hours : (Total =90 hours)	
~~**Unit:1**~~	~~**18 hours**~~
~~**Unit:2**~~	~~**18 hours**~~
~~**Unit:3**~~	~~**18 hours**~~
~~**Unit:4**~~	~~**18 hours**~~
~~**Unit V**~~	~~**18 hours**~~

Units	
I	Chemical Equilibria - Activity Concept, Equilibrium Constant And Applications, Ionisation Constants Of Acids And Bases. Concept Of pH,Hydrolysis Of Salts.
II	Buffers – Types, Range And Capacity, Dissociation Of Polyprotic Acids,Common Ion Effect, Salt Effect. Electrochemistry – Conductivity Of Electrolytes, Electrochemical Cells, Standard Electrode Potentials

III	Symmetry And Group Theory, Bonding Models In Chemistry – Ionic Bond, Covalent Bond, Coordination Chemistry - Theories Of Bonding In Coordination Compounds And Electronic Spectra Of Coordination Compounds
IV	Thermodynamics: First, Second And Third Law Of Thermodynamics. Gibbs And Helmholtz Energy And Chemical Equilibrium. Chemical Kinetics, Transition State Theory Ad Collision Theory, Heterogeneous Catalysis.
V	Organic Compounds – Structure And Bonding, Aliphatic And AromaticCompounds, Functional Groups, Nucleophiles And Electrophiles, Reactions And Mechanisms
Reading List(Print and Online)	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, IVEd., (1985). Physical Chemistry, .A. Alberty And R.J. Silbey
mmendedTexts	1. Inorganic Chemistry : Principles Of Structure And Reactivity – J.E.Huheey, E.A. Keiter and R.L. Keiter, IVEd. Physical Chemistry, Atkins 3. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001

Mapping with Programme Outcomes

S

trong - 3, Medium – 2, Low - 1

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Formatted: Centered

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER I
CORE-III

Course Code	**Course Name: INTRODUCTORY BIOLOGY**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Biology		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Acquire the knowledge of the cell biology and application. Explaining the role of cell organelles, metabolism, and bioenergetics. Understanding the about the morphology, structure, of DNA, RNAand different types of nucleic acid. Gaining the knowledge about of glucose, and fatty acid metabolism. Evaluation and comparison of the different enzyme role energyproduction.		
Units			
I	CELL STRUCTURE AND FUNCTIONS Definitions, Types, Eukaryotic and Prokaryotic cells, Principle of membrane organization, Cytoskeletal proteins, Types of cell division, Mitosis and Meiosis.		
II	PROTEINS Structure and functions of proteins, Amino acids and peptides, Proteins- Primary, Secondary, Tertiary, and Quaternary structures, Protein folding,hemoglobin and myoglobin.		
III	ENZYMES Mechanism of actions, Enzyme kinetics, Regulation of activities, Bioenergetics, Role of ATP, Biological oxidation, Respiratory chain and oxidative phosphorylation		
IV	METABOLISOM Overview of metabolism and catabolism, Carbohydrates, Biological significance, Glycolysis, Lipids of physiological significance, Cholesterol, Synthesis, Transport and Excretion, Glycoproteins and Extracellular matrix, Biooxidation, Fatty acid synthesis, Phospholipids and Membranes		
V	NUCLEIC ACIDS Structure, functions and replications of information macromolecules. Metabolism of purines and pyrimidine nucleotides. Organization, replication and repair of DNA. RNA and protein synthesis.		

Formatted Table
Formatted: Centered, Indent: Left: -0.1"
Formatted: Indent: Left: 0.12"
Formatted: Indent: Left: 0.12", Right: 0.06"
Formatted: Centered, Indent: Left: -0.1"
Formatted: Indent: Left: 0.12"
Formatted: Indent: Left: 0.12", Right: 0.13"
Formatted: Centered, Indent: Left: -0.1"
Formatted: Indent: Left: 0.12", Right: 0.19"
Formatted: Centered, Indent: Left: -0.1"
Formatted: Indent: Left: 0.12", Right: 0.19"
Formatted: Centered, Indent: Left: -0.1"
Formatted: Indent: Left: 0.12", Right: 0.19"

Reading List(Print and Online)	
Recommended Texts	Lehninger, Principles of Biochemistry, Cox and Nelson, V Edn,2008 L. Stryer, Biochemistry, 4th Edn., 1995 Haper's Illustrated Biochemistry, R.K, Murray, D.K. Granner and V.W. Rodwell, McGraw Hill , New Delhi, 2003.

Formatted Table

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Formatted: Centered

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Formatted: Centered

Strong - 3, Medium – 2, Low - 1

SEMESTER I

Elective Course-1

Course Code	**Course Name: Introductions To Materials Science**		**Credits 4**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of solid state physics		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of crystal structure and defects To gain knowledge on various properties such as electrical, magnetic, thermal, optical andmechanical properties of materials		

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the fundamental concepts of material science	
2	To apply the gained subject knowledge to understand the advanced concepts of nanoscience in second and third semesters	
3	To evaluate impact of presence of impurity and applied temperature on various properties of materials.	
4	To analyze the acquired knowledge and understanding on real time applications of various functional materials	

Unit:1	**CRYSTAL STRUCTURE AND DEFECTS**	**18 hours**

Structure of Matter- Amorphous, Crystalline, Crystals, Polycrystals, Symmetry, Unit Cells, CrystalStructures, Crystallographic Planes, Miller Indices, Chemical Bonding, Atomic Bonding in Solids,
Types of Bond: Metallic, Ionic, Covalent and Vander Waals; Crystal Defects.

Unit:2	**ELECTRICAL PROPERTIES**	**18 hours**

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.

Unit:3	**MAGNETIC PROPERTIES**	**18 hours**

Formatted Table

Formatted Table

Formatted Table

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.

Unit:4	**DIELECTRIC PROPERTIES**	**18 hours**
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.		
Unit:5	**THERMAL, OPTICAL & MECHANICAL PROPERTIES**	**18 hours**
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.		
Unit:6	**CONTEMPORARY ISSUES**	**2 hours**
Expert lectures, online seminars – webinars		
	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)

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).

Reference Book(s)

1.	Solid-State Physics: Introduction to the Theory, Patterson, James, Bailey, Bernard C.Springer (2018).
2.	Magnetic Materials : Fundamentals And Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	NPTEL: Material Science https://nptel.ac.in/courses/112/108/112108150/
2	NPTEL: Magnetic Properties https://www.youtube.com/watch?v=QQZ6EGf0Ju8

r

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	2	2	2	3	3	2	3	3	2	2
CO3	2	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	2	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2
Weightage	15	15	15	15	10
Weighted percentage (rounded of) Course Contribution to Pos	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
		LABORATORY SAFETY AND HEALTH	**Value Added Course – A**	**2**
Course Outcomes	1. Understanding the basic of Nanoscience and differentiate betweennano and bulk materials 2. Evaluate and critically review the theoretical and practical aspects ofnanomerials preparation and application. Understanding the concepts and techniques in nanotechnology 4. Critically assess and outline the nanotechnology for all areas of application 5. Demonstrate the new properties of nanomaterials for next generationneeds			
Course I	Core/Elective/**Soft Skill**			
Title of the Course:	- LABORATORY SAFETY AND HEALTH			
Course Objectives	Define and identify laboratory safety and health Understand and describe various safety issues and protocols Interpretation and application of safety protocols and laboratory rules. 4. Differentiate different types of laboratory accidents and safety protocols and personal protective equipments. 5. Evaluation and assessment safety regulations, personal protective equipments and First aid practices. 6. Apply the safety practices in real-time and awareness to the societalneeds.			
Units				
I	SAFETY REGULATIONS Standard Laboratory Procedures, Rules And Regulations. Lab Safety Practices.			
II	SAFETY REGULATIONS Employee Information, Safety Plans And Arrangement of Laboratories.			
III	CHEMICAL AND BIOSAFETY Chemicals Handing, MSDS Information, Labelling Of The Chemicals,Disposal Of The Chemical And Biological Wastes			
IV	SAFETY EQUIPMENTS Various Safety Equipments, Personal Protective Equipments, User Manuals, Arrangements, Training.			
V	FIRST AID First Aid Practices - Cardiac, Chemical Injury, Physical Injury. EmergencyCalls And Procedures. First Aid Kits.			
Reading List(Print and Online)	1. Introduction To Health And Safety At Work, Elsevier (2015)			
mmendedTexts	1. Environmental Health & Safety Procedure Manual, Harper College(2001)			

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
		Intellectural Property Rights	**Value Added Course – B**	**2**
Course Outcomes ~~(Use verbs like interpret, calculate, employ, generalise, evaluate, differentiate, critically assess, review, enumerate, identify, state, describe, explain, outline, select, recall, understand, compare and contrast, evaluate, critique, revise, summarise, demonstrate, draft, report, explain, obtain, recognise, respond, display)~~	Understanding research ethics Learn to protect our research finding Learn to file Patents Critically assess and outline the findings and Know How			
Course I	**Value Added Course – B**			
Title of theCourse:	**Intellectural Property Rights**			
Course Objectives	Define Intellectural Property Rights Understand and describe various types of IP rights To learn different types of IPS Differentiate different types of filing IPS To learn Know How and Trade Secrets Evaluate and assessment of all regulations for the above said IPS.			
Units				
I	Introduction: – Invention and Creativity – Intellectual Property (IP) – Importance- Protection of IPR			
II	Patents: IP- Patents- Copy rights and related rights- Trade marksp and right arising from Trademark registration- definitions- Applications Procedures			
III	International Convention relating to Intellectual Property- establishment of WIPO- Mission and Activities- History –General Agreement on Trade and Tariff (GATT)			
IV	Indian Postion Vs WTO and Strategies – Indian IPR- Word Patents- US patents- regulations			

Formatted Table

Formatted: Indent: Hanging: 0", Line spacing: single

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

V	Case Studies New Patents – copy right and related rights- Trame Marks- Know How-
Reading List(Print and Online)	Subbaram N.R " Handbook of Indian Patent Law and Paractice, S. Viswanathan, (Printer and Publishers) , Pvt. Ltd. 1998
mmendedTexts	Intellectual Proerty Today: Volume 8 May 2001, [www. Iptoday. Com]

Formatted: Centered

Mapping with Programme Outcomes

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

		INNOVATION AND ENTREPRENEURSHIP	**Value Added Course - C**		**2**	
CourseCode:		**INNOVATION AND ENTREPRENEURSHIP**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Value Added Course – C**				
Pre-requisite		Basic knowledge with data sets, graphs and scientific images.				

The main objectives of this course are to:

To enable the students to learn the various aspects of innovation and methods offostering Innovation
To understand the concept and theories of entrepreneurship
To recognize the qualities of entrepreneurs that contributed to their success.

Expected Course Outcomes:

On the successful completion of the course,

1	Crisis management/Risk Management - you must take advance from your clients before hand
2	Various options to start a business venture. Quality of the product matters much in the marker
3	Understanding the needs of the customer
4	Any idea can be innovative if its in accordance to people's need. Marketing strategies

Unit:1	**Introduction to Innovation**	18 hours

Creativity, Invention and innovation-Types of Innovation-Relevance of Technology for Innovation-The Indian innovations and opportunities

Unit:2	**Promoting and managing innovation**	18 hours

Innovators and Imitators-Patents, Trademarks, Intellectual Property-Exploring, Executing, Leveraging and renewing innovation-Enhancing Innovation Potential & Formulating strategies for Innovation

Unit:3	**Strategy for Commercializing Innovation**	**18 hours**

Innovation Process- Risks and barriers for introducing products and services-Selecting a Strategy, setting up the Investment and establishing organisation-Evaluating the Costs and impact of the Project

Unit:4	**Entrepreneurship**	**18 hours**

Entrepreneurship in global context – social and economic development- Entrepreneurship and social entrepreneurship – Meaning, Entrepreneurial attributes / indicators-Theories of entrepreneurship-Characteristics of an entrepreneurial venture, factors affecting entrepreneurial Growth

Formatted Table
Formatted Table
Formatted: Centered
Formatted: Centered
Formatted: Centered
Formatted: Centered

Unit:5	ENTREPRENEURSHIP DEVELOPMENT IN INDIA	**18 hours**
Growth and promotion of Entrepreneurship in India - Institutional arrangements - Entrepreneurial motivation - Values and Culture - Entrepreneurship in various sectors - Access to finance, market, R&D and Technologym- Policies and programmes related to entrepreneurship development		
Unit:6	**CONTEMPORARY ISSUES**	**2 hours**
Expert lectures, online seminars – webinars		
	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)

Robin Lowe and Sue Marriott, Enterprise: Entrepreneurship and InnovationConcepts, Contexts and Commercialization
John Bessant and Joe Tidd, Innovation and Entrepreneurship

Reference Book(s)

Rabindra N. Kanungo "Entrepreneurship and innovation", Sage Publications, NewDelhi, 1998.
Peter F. Drucker, Innovation and Entrepreneurship
EDII "Faculty and External Experts – A Hand Book for New Entrepreneurs Publishers: Entrepreneurship Development" Institute of India, Ahmadabad, 1986.
Philips, Bonefiel and Sharma (2011), Social Entrepreneurship, Global visionpublishing house, New Delhi.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

Mapping with Programme Outcomes

Strong - 3, Medium – 2, Low - 1

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER I

Nanoscience Practical I

Course Code	**Course Name: Nanoscience Practical- I**		**Credits 3**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Biology, Chemistry and Physics		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Acquire practical skills in the use of instruments, technologiesand methods in Biomolecules like glucose, urea, creatinine, DNA, proteins, Apply the practical knowledge in understanding the estimation, separation techniques. Provides opportunities to collect and examine samples fromblood and cells. Master the technical skills in buffer, medium, sterilizing,culturing, and charactering biological samples. To compare the structural diversity of healthy and diseasedcondition.		

Units	
I	PROTEIN ESTIMATION Lowry and Bradford methods
II	ESTIMATIONS OF BLOOD- Glucose, Blood urea, Uric acid, and Creatinine
III	SEPARATION AND CHARACTERIZATION OF PROTEIN Chromatography, Gel Filtration, Ion exchange, Affinity chromatography,TLC, Polyacrylamide, Agarose gel electrophoresis.
IV	DNA ESTIMATION Isolation of DNA and demonstration of apoptosis of DNA laddering
V	MICROSCOPY – FLUORESCENCE MICROSCOPE EXPERIMENTS Cell Counting, MTT assay for cell viability, and growth.

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

trong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II
CORE-IV

Course Code	**Course Name: Introduction To Nanoscience And Nanotechnology**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of Nanoscience and Nanotechnology		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: To understand fundamental concepts of nanoscience and technology To gain knowledge on size dependent various physical properties		
Expected Course Outcomes:			
On the successful completion of the course, student will be able to:			
1	To understand the fundamental concepts of nanoscience		
2	To apply the basic concepts of physics, chemistry and biology concepts to understand the advanced concepts of nanoscience		
3	To influence of size and morphology and other factors on various properties of materials.		
4	To analyze the acquired knowledge and understanding on real time applications of various applications		
Unit:1	**FUNDAMENTALS**		**18 hours**
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;			
Unit:2	**BASIC CONCEPTS**		**18 hours**
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 Oxide - Metal Oxide; Nano in Nature: Gecko Effect, Lotus leaf effect, Superhydrophobicity, Self-Cleaning and Antifogging – Colored Glasses and Dichroism.			
Unit:3	**UNIQUE PROPERTIES**		**18 hours**
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 – Superparamagnetism, Thermal – Melting point depression.			

Formatted Table
Formatted: Centered
Formatted Table
Formatted: Centered
Formatted: Centered
Formatted: Centered
Formatted Table
Formatted Table
Formatted Table

Unit:4	ADVANCED NANOSTRUCTURED MATERIALS	18 hours
Allotropes of carbon: Graphene, CNT, C-dots, Fullerenes – Inorganic: Organic hybrids – Ferrofluids- Zeolites- Core-shells – Nanostructures of Zinc Oxide: tetrapods, rings, springs, belt, rods, wires - Additive Manufacturing of 3D Nanoarchitected Metals – Nanorobots		
Unit:5	**ROAD MAP**	**18 hours**
Miniaturization of electronic materials and devices – Lithography techniques - Scaling issues – batch fabrication and circuit integration – MEMS and NEMS – Current and future challenges		
	TOTAL LECTURE HOURS	**90 hours**

Formatted Table

Formatted Table

Formatted Table

Text Book(s)	
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)
Reference Book(s)	
1.	NANO: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill (2017)
2.	Magnetic Materials : Fundamentals And Applications by Nicola A. Spaldin, Cambridge University Press, 2nd Edition, (2018)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	NPTEL: Introduction to Nanomaterials https://nptel.ac.in/courses/118/104/118104008/
2	NPTEL: Nanostructuresd Materials https://nptel.ac.in/courses/118/102/118102003/

Mapping with Programme Outcomes

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

CORE-V

Course Code:		**Preparations of Nanomaterials**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Core**	**4**	**0**	**0**	**4**
Pre-requisite		Basic knowledge with wet chemistry and materials				

Course Objectives:

The main objectives of this course are to:

To understand preparation procedures also the various factors that affects the size andmorphology of crystallites.

To gain knowledge on current status, future trends and scope for research.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand fundamental concepts in materials preparation with various Morphologies	
2	To apply the gained subject knowledge towards understanding the mechanisms involved physical, chemical and mechanical routes.	
3	To evaluate and understand the role of preparation method towards grain with narrow distribution and desired morphology.	
4	To analyze acquired knowledge and understanding on effect of grain morphology and its needs for technological advancements	

Unit:1	**BASICS IN MATERIALS PREPARATION**	**18 hours**

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.

Unit:2	**PHYSICAL ROUTES**	**18 hours**

High energy ball mill - Inert gas condensation Role of inert gases - Post oxidation process –Sputtering processes - Pulsed laser deposition – Rapid solidification – Arc discharge method- Fabrication of nanostructures and microfabrication using wet and dry etching-Lithography.

Unit:3	**CHEMICAL METHODS**	**18 hours**

Polyol route – Colloidal precipitation – Sol-Gel process– Chemical precipitation: Normal and Reverse reactions- Role of surfactant – Hydrolysis: Reaction kinetics – Hydrothermal – Salvothermal – Sonochemical – Microbial routes – Template route: DC and Pulsed electrodeposition and Electroless deposition – Combustion route.

Unit:4	**SPECIALIZED TECHNIQUES**	**18 hours**

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.

Unit:5	IMPORTANCE OF MORPHOLOGY	18 hours
Crystallites With Various Morphologies – Polymorphs – Surface Aspect Ratio – Grain size distributions – Surface area – Current Status and Forecast for The Future Trends		
	TOTAL LECTURE HOURS	**90 hours**
Text Book(s)		
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, A. K. Cheetham (Eds), Wiley-VCH Verlag (2004)	
4	B.S. Murty and S. Ranganathan, International Materials Reviews (1998) Vol. 43(3), 101	
Reference Book(s)		
1.	Nanoparticles And Nanostructured Films Preparation, Characterization And Applications, Janos H. Fendler (Ed) Wiley (1998)	
2.	H. Gleiter, Progress In Materials Science, Vol.33, p.223 (1989)	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	NPTEL: Nanotechnology, Science and Applications https://nptel.ac.in/courses/113/106/113106093/	
2	YOUTUBE: Introduction to Nanomaterials https://www.youtube.com/watch?v=qUEbxTkPIWI	

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	2	2	2	3	3	2	3	3	2	2
CO3	2	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	2	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2
CO2	3	3	3	3	2
CO3	3	3	3	3	2
CO4	3	3	3	3	2
CO5	3	3	3	3	2
Weightage	15	15	15	15	10
Weighted percentage (rounded of) Course Contribution to Pos	3	3	3	3	2

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

CORE-VI

Course Code	**Course Name Characterization Techniques of Nanomaterials –I**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Basic knowledge with concepts of physics.		
Links to other courses			
Learning Objectives:	1. Understand the properties of the light and interaction with matter 2. Distinguish the nanomaterials and bulk materials using X-ray. 3. Explore the chemistry of the materials Understanding the mechanical properties of the nanomaterials Study the magnetic and electrical properties.		
Course Outcomes	1. Understanding the purpose of characterization for the given materials 2. Explore the properties of nanomaterials for the particular applications 3. Understanding the principles of characterization techniques 4. Study the properties of nanomaterials 5. Understanding the instrumentation involved in the characterizationtechnique. 6. Understanding the suitability of the characterization for the particularmaterial. 7. Learn the interpretation of the results obtained from the characterization		
Units			
I	**Unit I Introduction to spectroscopy** Basic principles and applications of UV-Vis-NIR, FTIR, FT-Raman, Photoluminescence, NMR, ESR and Light Scattering methods.		
II	**Unit II X – ray techniques** X-ray powder diffraction –Quantitative determination of phases; Structure analysis, single crystal diffraction techniques - Determination of accurate lattice parameters - structure analysis-profile analysis - particle size analysis using Scherer formula- Particle Size Analyzer-Ellipsometry- thickness measurements		

III	**Unit III Electron Spectroscopy** X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy, X-Ray Characterization of Nanomaterials - EELS– EDAX and WDA analysis - Applications to nanomaterials characterization
IV	**Unit IV Mechanical properties measurement** Nanoindentation principles- elastic and plastic deformation -mechanical properties of materials in small dimensions- models for interpretation of Nanoindentation load-displacement curves- Nanoindentation data analysis methods-Hardness testing of thin films and coatings- MD simulation of nanoindentation.
V	**Unit IV Magnetic and electrical properties measurement** Vibration Sample Magnetometer, Impedance Spectroscopy- PPMS, - Measurement of Magnetic and electrical properties of nanomaterials.
Reading List(Print and Online)	Introduction to Spectroscopy *dl.iranchembook.ir* › ebook › organic-chemistry-2753 An Introduction to Surface Analysis by XPS and AES | Wiley ... *onlinelibrary.wiley.com* › doi › book EPMA - electron probe microanalysis *www.ems.psu.edu* › harbin › EPMA.ppt.pdf Physical Property Measurement System www.mrl.ucsb.edu › instruments › hcapPPMS
Recommended Texts	**References:** Elements of X-ray Diffraction B. D. Cullity, Addison Wesley, 1977 **2. Transmission Electron Microscopy: A Textbook for MaterialsScience** David B Williams, C Barry Carter, (1996) Plenum Press, New York Impedance Spectroscopy: Theory, Experiment, and Applications, E. Barsoukov and J. Ross Macdonald (Editors) (2000) John Wiley &Sons (P)Ltd. **Fundamentals of Fourier Transform Infrared Spectroscopy,** Brian C Smith, (1995) CRC Press Nanoindentation, By Anthony C Fischercripps, Anthony C. , Springer science and Bussiness media publications, 2011 Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers, Daniel L. Schodek, Paulo Ferreira, Michael F. Ashby, Elsevier, 2009.

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

Elective course-2

Course Code	**Course Name: Nanobiotechnology**		**Credits 3**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Student should have the fundamental knowledge in biomaterials, Biological Cell, functions of cell, biochemistry of biomolecules and its relation to cell function		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Acquire the knowledge of the cell biology and application. Explaining the role of cell organelles, metabolism, and bioenergetics. Understanding the about the morphology, structure, of DNA, RNA and different types of nucleic acid. Gaining the knowledge about of glucose, and fatty acid metabolism. Evaluation and comparison of the different enzyme role energy production.		
Course Outcomes	On the successful completion of the course, student will be able to Understanding the basic of Biology and Nano science anddifferentiate between Nano materials and bulk materials Evaluate and critically review the theoretical and practical aspectsof Nano materials application. Explain the concepts in Nano biotechnology Critically assess and outline the nanotechnology for all areas of application Demonstrate the new properties of Nano materials for nextgeneration needs		

Course Objectives	**1.** Understand the basics of bioinspired strategies for the fabrication of Implants in Nanobiotechnology- **2.** Learn the importance of bioactive nanomaterials in bone graftingand tissue engineering **3.** Recognize the significance of Biomolecules in the fabrication ofNanostructures – **4.** Study the applications of Polymer nanofibers in Tissue engineeringand its merits and demerits- **5.** Know the importance of vesicles and lipids in sensor and also its application in drug delivery –
	6. Understand the overall basics of biomolecules and its applicationin Nano biotechnology
Units ~~Total- 48hrs~~	
I ~~**9h**~~	Bio-mineralised Inorganic Nanomaterials – Nanostructures and Dynamics of Biocompatible surfactant monolayers and bilayers – Bio-interface, Bio- conjugation, Bio-matrix based on bioinspired phospholipids polymers.
II ~~**10h**~~	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.
III ~~**9h**~~	DNA based artificial nanostructures: fabrication, properties and applications – Nucleic acid engineered nanomaterials and their applications- RNA, DNA
IV ~~**10h**~~	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
V ~~**10h**~~	Vesicles and liposomes in sensor technology –Self-assembling nanostructured injectable polymeric gels for drug delivery - Engineering surface erodable polyanhydrides with tailored microstructure for controlled drug and protein delivery

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Reading List(Print and Online)	https://onlinelibrary.wiley.com http :// www.routledgehandbooks.co
mmendedTexts	Challa S.S.R. Kumar (Ed) Biological and pharmaceutical nanomaterials : Wiley – VCH Verlag GmbH & Co, KgaA. Ninmeyer C.M, Mirkin C.A (Eds) 2005. Nano biotechnology H.S. Nalwa (Ed) Handbook of Nanostructured Bioaterials and their applications in Nano biotechnology, American Scientific Publishers.2005

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

trong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-II

Elective Course-3

Course Code	**Course Name: INTRODUCTION TO NANOTOXICOLOGY**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Students who are taking this course should know about the fundamentals of biological cell and tissues and also the basic knowledge in materials.		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Understanding the basic of Toxoicology 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 toxicology Critically assess and outline the nanoscience for nanotoxicology Demonstrate the new properties of Nano materials and its significance in toxicology		
Course Outcomes	On the successful completion of the course, student will be able to Understanding the basic of Toxoicology and Nano science and differentiate between nanomaterials and bulk materials Evaluate and critically review the theoretical and practicalaspects of Nano materials application Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano toxicology Critically assess and outline the nanoscience for nanotoxicology Demonstrate the new properties of Nano materials and its significance in toxicology		

Course Objectives	Learn the types of hazard and its application- Understand the importance of nanotoxicant and its effect inhealth - Study the basics of biomolecules and its application innanotoxicology - Comprehend the effect of Nanotoxicology – Understand the response of nanomaterials in Nano engineeringdevices and evaluate its significance -
Units ~~**Total -48hrs**~~	
I ~~**10h**~~	**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.
II ~~**10h**~~	**NANOMATERIALS** 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.
III ~~**8h**~~	**NANOPOLLUTION** Nanomaterial's in environment, Source of pollution, Transport through environment.
IV ~~**10h**~~	**NANOMATERIAL EXPOSURE MEASUREMENT** Nano sized materials exposure to human, Measurement methods, Threshold values-permissible limits.
V ~~**10h**~~	**PORTALS OF NANOMATERIALS ENTRY** Types of portals entry, Target tissue, Routes of entry of nano pollutants, Absorption, Distribution mechanism on target tissue.
Reading List (Print and Online)	https://www.intechopen.com/books/toxicology-new-aspects
mmendedTexts	Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, *CRC Press, 2008* Nanotechnology: Environmental Health and Safety, Risks, Regulation and Management, **Matthew Hull** and **Diana Bowman, Elsevier, 2010** Principles and Methods of Toxicology. Edited by A.W. Hayes. Taylor and Francis, 2008.

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-III : Core-VII

Course Code	**Course Name: NANOELECTRONICS AND NANOSENSORS**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Student should have the fundamental knowledge in biomaterials, Biological Cell, functions of cell, biochemistry of biomolecules and its relation to cell function		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Learning New Perspective in Nanoelectroncs Explaining the size and shape enabled properties of nanomaterials Understanding the functioning of various electronic devices. Understanding and assessment of electronic properties for sensor		

	development and application. Compare and evaluate the nano enabled electronic properties for development of smart devices. Conceptualization of nanoscale electronic phenomena for societal applications
Units	
I	Basice Concept of Nanoelectrics- New Perspectives- New Ohm's Law- Density of states- Fermic Function- Types of Conductance- Ballastic Conductance- Resistance: Ballistic to Diffusive- Nanotransistors
II	SEMICONDUCTOR NANODEVICES Single-Electron Devices, Nano Scale MOSFET – Resonant Tunnelling Transist-or - Single-Electron Transistors;; Nanorobotics And Nanomanipulation; Molecular Nanowires-Organic LED, Organic FETs- CNT And Graphene FET, Si NW FET.
III	ELECTRONIC AND PHOTONIC MATERIALS Single Electron Tunnelling Phenomena- Coulomb Blockade - Coulomb Staircase - RSD and Resonant Tunnelling Transistor- Quantum Structures Based Leds - OLED and Photo Detectors- Magnetic Quantum Dots And Their Applications.
IV	NANOSENSORS BASICS Micro and Nano - Sensors, Fundamentals of Sensors, Biosensor, Micro Fluids, MEMS And NEMS, Packaging and Characterization of Sensors, Method of Packaging At Zero Level, Dye Level And First Level, Thermal Energy Sensors, Temperature Sensors, Heat Sensors-
V	NANOSENSORS Electromagnetic Sensors- Electrical Resistance 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 - Optical and Radiation Sensors - Gas Sensor - Bio Sensors - DNA Based Biosensors-Packaging and Method of Packaging.
Reading List (Print and Online)	1. Nano Electronics And Information Technology, W. Ranier, Wiley (2003). Nano Systems, K.E. Drexler, Wiley (1992).
Recommended Texts	Introduction To Molecular Electronics, M.C. Pettey 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)

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Indent: First line: 0"

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

trong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

Course Name Nanoscience Practical II

Course Code		**Credits**

Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Fundamental and theoretical knowledge on preparation and characterization techniques		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Acquire practical skills in the use of instruments, technologies and methods to fabricate nano materials and their characterization Apply the practical knowledge in understanding the structural ofthe materials Provides opportunities to synthesize the materials using different approaches Master the technical skills in handling lab equipments,characterizing the acquired data and analyze using appropriate tool Understand the role of environmental conditions on the preparation of nano-materials		
Practical-II	**Synthesis and Characterization of Biomolecules and Biomaterials**		
	Synthesis of Silver Nanoparticles By Chemical Reduction Method And Their UV-VIS Absorption Studies. Synthesis of Gold Nanoparticles By Chemical Reduction Method And Their UV-VIS Absorption Studies. Synthesis of Silver Nanoparticles By Polyol Method And Their UV-VIS Absorption Studies. Synthesis of Gold Nanoparticles By Polyol Method And Their UV-VIS Absorption Studies. Study of chemical kinetics using UV-Vis spectroscopy.		
Reading List(Print and Online)	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, IVEd., (1985). Physical Chemistry, .A. Alberty And R.J. Silbey		
mmendedTexts	1. Inorganic Chemistry : Principles Of Structure And Reactivity – J.E.Huheey, E.A. Keiter and R.L. Keiter, IVEd. Physical Chemistry, Atkins 3. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001		

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

trong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER III
Core-VIII

PROPERTIES OF NANOMATERIALS		
Expected Course Outcomes:		
On the successful completion of the course, student will be able to:		
1	Understand fundamental concepts and influence of grain size and morphology on properties of nanomaterials	
2	Apply the gained subject knowledge towards understanding the mechanisms involved in functional materials	
3	Evaluate and understand the nanomaterials superior properties by comparing with bulk materials	
4	Analyze acquired knowledge and understanding on effect various processing parameters and its needs for technological advancements	

Unit:1	**ELECTRONIC PROPERTIES**	**18 hours**
Role of Size and Shape in Electronic Properties, Band Structures, Brillouin Zones, Channel Materials - Depletion region - Confinement and Transport In Nanostructure Types of conduction - Diffusive and Ballistic - Ballistic Transport - Coulomb Blockade.		

Unit:2	**MAGNETIC PROPERTIES**	**18 hours**
Size dependence - Surface magnetism - Magnetic anisotropy and domains in small particles - Magnetization and nanostructures - Substrate effects, Oscillatory exchange coupling, Spin polarized tunneling - Magnetism in reduced dimensional systems: zero, one and two – Magnetoresistance: OMR, AMR, GMR, TMR, BMR and CMR.		

Unit:3	**DIELECTRIC PROPERTIES**	**18 hours**
Carrier transport through grain boundaries –Impedance spectroscopy – Grain boundary Schottky potential barrier height (Φ_b) model: effect of bias and temperature – Voltage tunable capacitors - Dielectric breakdown - Nanodielectrics: future insulating materials - Ferroelectrics and Multiferroics		

Unit:4	**OPTICAL PROPERTIES**	**18 hours**
Band Gap Engineering - Morphology and size effects of nanocrystalline semiconductors and metals – Effective mass approximation theory – Nanoshells - Crystallite size distribution estimation from absorbance – Fluorescence: Stokes and Anti Stokes Shifts – Up and Down conversion.		

Unit:5	**MECHANICAL PROPERTIES**	**18 hours**
Micro Hardness, Nanoindentation, Fracture Toughness, Superplasticity, Plastic Nature of Nanoceramics, Nanomembrances - Inter Connected Pores - Bulk Nanostructured Materials - Influence of Porosity. Hall-Petch Relation, Microstructure – Dislocation Interactions At Low And High Temperatures; Effects of Diffusion on Strength And Flow of Materials; Methods of Enhancing or Retarding Diffusion; Grain Boundary Sliding and Migration.		

Unit:6	**CONTEMPORARY ISSUES**	**2 hours**
Expert Lectures, Online Seminars – Webinars		

Formatted Table

	TOTAL LECTURE HOURS	**90 hours**

Text Book(s)	
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, A. K. Cheetham (Eds), Wiley-VCH Verlag (2004)
4	Dan Guo *et al*, Journal of Physics D: Applied Physics (2018) Vol. 47, 013001
Reference Book(s)	
1.	Impedance Spectroscopy: Theory, Experiment, and Applications, E Barsoukov and JRoss Macdonald Wiley (2018)
2.	H. Gleiter, Progress In Materials Science, Vol.33, p.223 (1989)
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	NPTEL: Defect Structure & Mechanical Behaviour of Nanomaterials https://www.youtube.com/watch?v=bwZW96c743A
2	YOUTUBE: Introduction to Nanomaterials https://www.youtube.com/watch?v=qUEbxTkPIWI

Mapping with Programme Outcomes

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	
CO2	3	2	2	3	3	2	3	3	2	
CO3	3	2	2	3	3	3	3	2	2	
CO4	3	3	3	2	2	2	3	3	2	
CO5	3	2	2	3	2	3	2	2	3	

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-III

Core-IX

Course Code	**Course Name: Characterization Techniques of Nanomaterials –II**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Student should have the fundamental knowledge in biomaterials, Biological Cell, functions of cell, biochemistry of biomolecules and its relation to cell function		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Visualize the nanomaterials to understand the morphology Understand nanostructure of materials Understand the microstructure of materials Reveal the thermal behavior of the nanomaterials Studying bio-materials using proper tools		
Course Outcome	Understanding the purpose of characterization for the given materials Explore the properties of nanomaterials for the particular applications Understanding the principles of characterization techniques Study the properties of nanomaterials 5. Understanding the instrumentation involved in the characterization technique. 6. Understanding the suitability of the characterization for the particularmaterial. 7. Learn the interpretation of the results obtained from the characterization		
Units			
I	**Unit I Morphological studies** Principles, Overview of Instrumentation and Sample preparation, Experimental techniques adopted in: Scanning Electron Microscopy: SEM and FESEM -Transmission Electron Microscopy (TEM) – HRTEM-application for analysis of Nanomaterials.		
II	**Unit II Materials defects studies** Scanning Tunnelling Microscopy(STM), Atomic Force Microscopy AFM)-Non-contact-contact- Tapping- conducting mode-.Near Field Scanning Optical Microscopy; Scanning capacitance Microscopy- Magnetic Force Microscopes MFM)- Chemical Force Microscope (CFM)- Applications for analysis of nanomaterials .		

Formatted: Centered

Formatted: Centered

III	**Unit III 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.
IV	**Unit IV Thermal analysis** Principle and Instrumentation of Thermogravimetry; Differential Thermal Analysis and Differential scanning calorimetry-Importance of thermal analysis for nanostructures.
V	**Unit V Bio-materials characterization** New Advances and challenges in biological and biomedical materials characterizations- Dynamic light scattering spectroscopy. Confocal Microscopes - Confocal Raman – Application in Nanobiotechnology. Fluorescence Microscope
Reading List(Print and Online)	*www.technologynetworks.com* › sem-vs-tem-331262 *onlinelibrary.wiley.com* › abs › 9780470022184.hmm319 1. www.umassmed.edu › maps › confocal-explanation
mmendedTexts	**References:** J.Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lym, "ScanningElectron Microscopy and X-ray Microanalysis", 2003. S.L. Flegler, J.W. Heckman and K.L. Klomparens, "Scanning and Transmission Electron Microscopy: An Introduction", WH Freeman & Co, 1993. P.J.Goodhew, J.Humphreys, R.Beanland, "Electron Microscopy and Analysis", R.Haynes, D.P.Woodruff and T.A.Talchar, "Optical Microscopy of Materials", Cambridge University press, 1986. R.M.Rose, L.A.Shepard and J.Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd,

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to POs	3	2	3	3	3

Formatted: Centered
Formatted: Centered
Formatted: Centered
Formatted: Centered
Formatted: Centered

Strong - 3, Medium – 2, Low – 1

SEMESTER-III

Elective course-3

Course Code	**Course Name: Biomaterials and Nanobiotechnology for Tissue Engineering**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Students who are taking this course should know about the fundaments of biomaterials, basics in biological cell, tissues and the metabolism of carbohydrates and Proteins and also able to understand the mechanism of cellular function		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Learn the types of biomaterials, biomaterial used in implant andits application in orthopedics and dental- Understand the importance of biomaterials used for cartilage and Vascular implant and its mode of failure-		

Elective course-3

Course Outcomes	On the successful completion of the course, student will be able to Understanding the basic of Biology and Nano science anddifferentiate between nanomaterials and bulk materials Evaluate and critically review the theoretical and practicalaspects of Nano materials application Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano biotechnology Critically assess and outline the nanotechnology for all areas of application Demonstrate the new properties of Nano materials for next generation needs
	Study the basics of tissue engineering and its application in vitalorgans and mode of bladder implant failure- Comprehend the biological response to nanomaterials –Understand the response of proteins in tissue regeneration andevaluate the significance of host defense mechanism-
Units ~~**Total–48hrs**~~	
I ~~**10h**~~	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
II ~~**10h**~~	CARTILAGE IMPLANT 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
III ~~**8h**~~	BLADDER IMPLANT Bladder overall view, Bladder implant materials used – modes of bladder implant failure – stress and strain imbalances at the tissue implant interface
IV ~~**10h**~~	BIOLOGICAL EFFECT 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

Formatted: Centered

Formatted: Centered

Formatted: Centered

V	ADVANTAGE OF NANOMATERIALS
~~10h~~	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
Reading List(Print and Online)	https://www.verywellhealth.com/tissue-engineering-4580368 https://www.liebertpub.com/doi/10.1089/ten.tec.2019.0344
mmendedTexts	William A. Goddard, Sergey Edward Lyshevski, Donald W. Brenner (Ed) Handbook of Nanoscience, Engineering and Technology CRC press 2003 Joachim Schummer, Davis Baird (Ed) Nanotechnology Challenges: implications for philosophy, Ethics and society ; World scientific ; 2006 William Sims Bainbridge, Mihail C. Roco (Ed) Societal implication of Nanosciences and Nanotechnology;Springer;2001 Jon J. Kellar (Ed) Functional fillers and nanoscale minerals; new markets/ new horizonsSME science; 2006 Davis Baird, Alfred Nordmann, Joachim Schummer (Eds) Discovering the nanoscale; IOP press; 2004

Formatted: Centered

Mapping with Programme Outcomes

trong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

SEMESTER-III

OPEN ELECTIVE-2
CORE INDUSTRY MODULE

Course Code	**Course Name:** - INDUSTRIAL NANOTECHNOLOGY		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Student should have the fundamental knowledge in biomaterials, Biological Cell, functions of cell, biochemistry of biomolecules and its relation to cell function		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: Identification of industrially relevant materials Summarize suitability of nanomaterials for industries. Interpretation and employment of nanomaterials for industrial needs. Evaluation and critical assessment of nanomaterials for various industrial application. Review the industrial development and relevant nanomaterials supply with required functionalities.		
Course Outcome	1. Understanding the role of different nanomaterials and their importance. 2. Development of new combination of nanomaterial based on theirproperties for future needs. Assess the role of nanomaterial for enhancing the application effect. 4. Critically assess nanomaterial ability for making industrial levelapplication. 5. Demonstrate the new properties of nanomaterials for next generationneeds.		

Units	
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-QD optical memory-Present and future trends.
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- AFMBased Recording Technology.
III	NANO ELECTRO MECHANICAL SYSTEMS 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.
IV	INDUSTRIAL APPLICATIONS OF NANOMATERIALS Nanoparticles And Micro Organism, Nano-Materials In Bone Substitutesand Dentistry, Food and Cosmetic Applications,
V	INDUSTRIAL APPLICATIONS OF NANOMATERIALS
	Textiles, Paints, Catalysis, Drug Delivery and Its Applications, Biochips -Analytical Devices, Biosensors.
Reading List(Print and Online)	1. Nano Electronics, Parag Diwan and Ashish Bharadwaj, Pentagen Press(2006) Principles of Superconductive Devices Aad Circuits, C.W. Turner and T. Van Duzer (1981) 3. Principles of Optical Electronics, A. Yariv, Wiley(1984)
mmendedTexts	1. Introduction To Molecular Electronics, M C Petty, M R Bryce, D Bloor(Eds.), Edward Arnold (1995) 2. Current Opinion In Solid State & Materials Science, D.D.C. Bradley,Vol. 1, 789 (1996) Nano Electronics And Information Technology, Rainer Waser, Wiely (2003)

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	2	3	3	3
CO2	3	2	2	3	3	2	3	3	2	2
CO3	3	2	2	3	3	3	3	2	2	2
CO4	3	3	3	2	2	2	3	3	2	3
CO5	3	2	2	3	2	3	2	2	3	3

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	3	3
CO2	3	2	3	3	3
CO3	3	2	3	3	3
CO4	3	2	3	3	3
CO5	3	2	3	3	3
Weightage	15	10	15	15	15
Weighted percentage (rounded of) Course Contribution to Pos	3	2	3	3	3

Strong - 3, Medium – 2, Low - 1

Course Code	**Course Name Nanoscience Practical III**		**Credits**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	Fundamental and theoretical knowledge on preparation and characterization techniques		
Links to other courses			
Learning Objectives:	The main objectives of this course are to: 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 ofthe materials Provides opportunities to synthesize the materials using different approaches Master the technical skills in handling lab equipments,characterizing the acquired data and analyze using appropriate tool Understand the role of environmental conditions on the preparation of nanomaterials		
Part:1	**Characterization of CompoundNanomaterials**		
	Synthesis of Tio_2 Nanoparticles By Sol-Gel MethodAnd Characterize Using XRD And SEM Analysis. Synthesis of Ceria Nanoparticles And CharacterizeUsing XRD And SEM Analysis. X-Ray Diffraction Studies Of Synthesised Of Tio_2 Nanoparticles And Measuring The Crystallite Size. Synthesis Of Ceria Nanoparticles By Co-Precipitation Method.		
Part:2	**Characterisation of Specific Surface Properties**		
	SERS Studies Of Gold and Silver Nanoparticles Synthesis Of Quantum Dots AndPhotoluminescence Studies. Characterization of Carbon dots using UVSpectroscopy		
	Band gap studies of Metal oxide semiconductors using UV-Vis Spectroscopy		
Reading List(Print and Online)	4. Fundamentals Of Analytical Chemistry - Skoog, West and Holler,Saunders College, Publishing, VII Ed, (1996). 5. Text Book Of Quantitative Inorganic Analysis – A.I. Vogel, Elbs, IVEd., (1985). Physical Chemistry, .A. Alberty And R.J. Silbey		

mmendedTexts	4. Inorganic Chemistry : Principles Of Structure And Reactivity – J.E.Huheey, E.A. Keiter and R.L. Keiter, IVEd. Physical Chemistry, Atkins 6. Text Book Of Quantitative Chemical Analysis – A.I. Vogel, VI Ed,Pearson Education Ltd, 2001

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

trong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to Pos	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

Lab Manuals	
1	Das, S. and Saha, R. 2020. Microbiology Practical Manual. CBS Publishers and Distributors (P) Ltd., New Delhi, India.
2	Arora, B. and Arora, D.R. 2009. Practical Microbiology. 2nd ed. CBS Publishers and Distributors (P) Ltd., New Delhi, India.
3	Jha, D. K. Laboratory Manual on Plant Pathology. 2nd ed. Pointer Publishers, Jaipur, India.
4	Chmielewski, J. G. and Krayesky, D. 2013. General Botany laboratory Manual. AuthorHouse, Bloomington, USA.
5	Jha, D. K. 2018. Laboratory Manual on Plant Pathology (English). Pointer Publishers, Jaipur.
6	McMahon, K., Levetin, E. and Reinsvold, R. 2001. Laboratory Manual for Applied Botany. McGraw-Hill Education, New York, USA.
7	Bendre, A. M. 2010. A Text Book Of Practical Botany – 1. Rastogi Publications, Meerut, India.
8	Sivakumar, K. 2016. Algae- A Practical Approach. MJP Publishers, Chennai, India.
9	Gupta, V.K., Tuohy, M.G., Ayyachamy, M., Turner, K.M. and O'Donovan, A. 2013. Laboratory Protocols in Fungal Biology: Current Methods in Fungal Biology. Springer, London, UK.
10	Garg, N., Garg, K. L. and Mukerji, K. G. 2010. Laboratory Manual of Food Microbiology. IK International Publishing House Pvt. Ltd., New Delhi, India.
11	Morello, J.A., Mizer, H.E., Granato, P.A. 2004. Laboratory Manual and Work Book in Microbiology. McGraw-Hill Education, New York, USA.

SEMESTER-IV
Core-XII

Course Code	**Course Name: Biomedical Nanotechnology**		**Credits 4**
Lecture Hours : (L) per week	**Tutorial Hours : (T) per week**	Lab practice Hours : (P) per week	Total: (L+T+P) Hours per week
Course Category:	**Year & Semester :**	Admission Year:	
Pre requisite:	The Student should have the fundamental knowledge in biomaterials, Biological Cell, functions of cell, biochemistry of biomolecules and its relation to cell function		
Links to other courses	The Student should know about the fundaments of biological system and also the concept of Nano materials fabrication technology		
Learning Objectives:	Understanding the basic of Bioceramics in Nano science and differentiate between nanomaterials and bulk materials Evaluate and critically review the theoretical and practical aspects of Tissue engineering methods and its application- Comprehending the novel function resulted from the nanoscale structures using scientific and technological principles in Nano biotechnology – Critically assess and outline the nanotechnology in the area of Drug delivery–		
Course Outcomes	On the successful completion of the course, student will be able to Understanding the basic of Biomedical sciences and Nano scienceand differentiate between nanomaterials and bulk materials Evaluate and critically review the theoretical and practical aspectsof Nano materials application. Summarize the concepts in Biomedical nanotechnology Critically assess and outline the nanotechnology for all areas of biomedical application Demonstrate the new properties of Nano materials for nextgeneration needs		
Units ~~**Total 90hrs**~~			
I ~~**18h**~~	BIO CERAMICS FOR IMPLANT COATING Calcium phosphates - hydroxy epilates Ti_6Al_4V and other biomedical alloys - implant tissue interfacing – metal organic CVD – use of tricalcium phosphate – biomimetic and solution based processing – osteoporosis – osteoplastic – regeneration of bones by using bio compactable ceramics		

II ~~16h~~	TISSUE ENGINEERING Scaffolds for tissue fabrications – materials for scaffolds – materials for hydrogel scaffolds – scaffolds fabrications technologies – textile technologies – particulate –leaching techniques – phase separation – design of three-dimensional pore architecture – nano-featured and bioactive scaffolds – nano-fiber scaffolds – nanocomposite scaffolds – – scaffolds for stem cells – micro and nanopatterned scaffolds -scaffolds and stem cells – Engineering biomaterial to control cell function – fibrous proteins and tissue engineering
III~~I~~ ~~18h~~	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 - future line of action – Gene delivery
IV ~~18h~~	NANOPHARMACY Bio interactive hydro gels – PEG coating and surface modifications – PEG hyrogels patterned on surfaces – PEG based hydrogels- Nanopharmacy- multi-targeted drugs – delivery of nucleic acids- barriers to therapeutic applications – interaction of organic molecules of the drug with pathological tissue – ligand targeted nanoparticles drug delivery
V ~~18h~~	NANOMEDICINE 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-methods of changing surface characteristics- future prospects.
Reading List(Print and Online)	https://link.springer.com/content/pdf/10.10090Fs11834-013-6063- 0.pdf http://nopr.niscair.res.in/bitstream/123456789/5224/1/IJEB2045(2)20160-165.pdf

Formatted: Centered

Formatted: Centered

Formatted: Centered

Formatted: Centered

Recommended Texts	Robert.W.Kelsall, Ian.W.Hamley, Mark Geoghegan (Ed), Nano Scale Science And Technology, John Wiley and son, ltd., 2005 H.Fujita (Ed), Micromachines As Tools For Nanotechnology,Springer, 2003 Mick Wilson Kamali Kannangara Geooff Smith Michelle, Simmons Urkhard Raguse, Nano Technology, Overseas India private Ltd., 2005. Gunter Schmid , Nano Particles, Jhon wiley and sons limited, 2004 K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006 Malsch, N.H., "Biomedical Nanotechnology", CRC Press. (2005). Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH. (2007) 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).

Formatted: Indent: First line: 0"

Mapping with Programme Outcomes

Strong - 3, Medium – 2, Low - 1

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

Mapping with Programme Specific Outcomes

CO/PSO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low – 1

SEMESTER-IV

Formatted: Centered, Indent: First line: 0"

Formatted: Body Text, Centered

Elective Course-4

Semester	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
IV Sem		**NANOTECHNOLOGY FOR FOOD AND AGRICULTURE**	**Elective**	**4**

Formatted Table

	1. Understanding the basic of Nanoscience and differentiate between nano and bulk materials 2. Evaluate and critically review the theoretical and practical aspects ofnanomerials preparation and application. Understanding the concepts and techniques in nanotechnology 4. Critically assess and outline the nanotechnology for all areas of application 5. Demonstrate the new properties of nanomaterials for next generationneeds

Formatted Table

Title of the Course:	**- NANOTECHNOLOGY FOR FOOD AND AGRICULTURE**
Credits:	4

Formatted Table

Course Objectives	1. Define and identify functional materials for food industry. 2. Understand and describe food and agricultural processes. 3. Interpretation and application of the theories and protocols for soil andfood nutrient management. 4. Differentiate different types of nanomaterials food sensing, nutrient management and packaging application. 5. Evaluation and assessment of various functional materials for sensing,nutrient management and packaging processes. 6. Development and employment of new nanoenabled functional materials and protocols for societal applications.
Units	
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.
II	FUNCTIONAL MATERIALS Functional Materials For Food And Agriculture Use - Super Absorbent Polymers, Coatings, Aerosols. Zeolites, Nano-Clays, Nano Emulsion,
III	NANOFERTILIZERS Nanofertilizer, Synthesis And Characterization. Fungicides, Herbicides – Pesticides. Types Of Nano-Formulations – Encapsulation Of Pesticides. Release Studies, Smart Delivery, Bio- Efficacy And Bio-Safety.
IV	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.
V	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
Reading List (Print andOnline)	1.Nano And Microencapsulation For Foods, Hae-Soo Kwak, Wiley (2018
Recommended Texts	1. Nanotechnologies In Food And Agriculture, Mahendra Rai, Cau Ribeiro, Luiz Mattoso, Nelson Duran, Springer (2015) 2. Nanotechnology Applications In Food, Alexandru Grumezescu, Alexandra Oprea, Academic Press (2017)

Formatted: Indent: First line: 0"
Formatted: Centered
Formatted: Centered
Formatted: Centered
Formatted: Centered
Formatted: Centered
Formatted: Indent: First line: 0.03"
Formatted: Indent: Hanging: 0.03"
Formatted: Indent: First line: 0"

Mapping with Programme Outcomes

Strong - 3, Medium – 2, Low - 1

Mapping with Programme Specific Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	3	3	2	3	3	3
CO2	3	3	2	3	3	3	2	3	2	2
CO3	3	3	2	3	3	3	2	2	2	2
CO4	3	3	2	3	3	3	2	3	2	3
CO5	3	3	2	3	3	3	2	2	3	3

CO/PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	2	2	3
CO2	3	3	2	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	3
CO5	3	3	2	2	3
Weightage	15	15	10	10	15
Weighted percentage (rounded of) Course Contribution to POs	3	3	2	2	3

Strong - 3, Medium – 2, Low - 1

PROJECT (8 credit)