M.Sc. Nanoscience and Technology

Syllabus

UNIVERSITY DEPARTMENT

Program Code: NSTA

2023 – 2024 onwards

BHARATHIAR UNIVERSITY

(A State University, Accredited with "A++" Grade by NAAC,
Ranked 21st among Indian Universities by MHRD-NIRF)

Coimbatore - 641 046, Tamil Nadu, India

Program Educational Objectives (PEOs)	
The M.Sc. Nanoscience and Technology program describe accomplishments that graduates are expected to attain within five to seven years after graduation.	
PEO1	Outshine in academics and research in different motifs of Nanoscience and Nanotechnology through post graduate education.
PEO2	Solid foundation in their respective core subjects such as physics, chemistry and biology in addition to nanoscience and technology.
PEO3	In-depth knowledge in synthesis and characterization of novel nanomaterials with multiple applications.
PEO4	Good theoretical and practical knowledge so as to comprehend, analyze, design, and create products and solutions for the real life problems.
PEO5	Professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate nanotechnology to address energy, environmental and biomedical applications.
PEO6	Academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career.
PEO7	Interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

Program Specific Outcomes (PSOs)	
After the successful completion of M. Sc. Nanoscience and Technology program, the students are expected to	
PSO1	Understand and apply principles of physics, chemistry and engineering for understanding the scientific phenomenon in nano domain.
PSO2	Understand and apply mathematical techniques for describing and deeper understanding of nano systems.
PSO3	Understand and apply quantum mechanical methods for particles in various physical systems and processes.
PSO4	Understand and apply inter-disciplinary concepts and computational simulation for understanding and describing the natural phenomenon.
PSO5	Understand and apply principles of quantum mechanics for understanding the nano systems in quantum realm.
PSO6	Provide exposure in various specialization of Nanotechnology.
PSO7	Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of phenomenon at nanoscale and nanosystems.
PSO8	Engage in research and life-long learning to adapt to changing environment.
PSO9	Having adaptive thinking and adaptability in relation to environmental context and sustainable development.
PSO10	Having a clear understanding of professional and ethical responsibility.

Program Outcomes (POs)	
On successful completion of the M. Sc. Nanoscience and Technology program	
PO1	Demonstrate knowledge on the physics/chemistry/biotechnology and basics of nanoscale science and technology for their multifunctional applications.
PO2	Demonstrate ability to synthesis and characterize the materials in general and also nanomaterials.
PO3	Project their skill in lithography and nanofabrication.
PO4	Having expertise in processing of nanomaterials, MEMS and bio MEMS as per needs and specifications.
PO5	Demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks including material science, physics, chemistry and nanobiotechnology.
PO6	Demonstrate skills to use synthesis, processing and imaging equipments to analyze samples.
PO7	Able to propagate their knowledge to address problems of social relevance such as energy, environment and medicine through their specific electives.
PO8	Understanding the impact of nanomaterials on the society including environment, health and ecosystem.
PO9	Able to plan and execute their own innovative ideas in the form of projects, product design and development.
PO10	Develop confidence for self-education and ability for life-long learning.

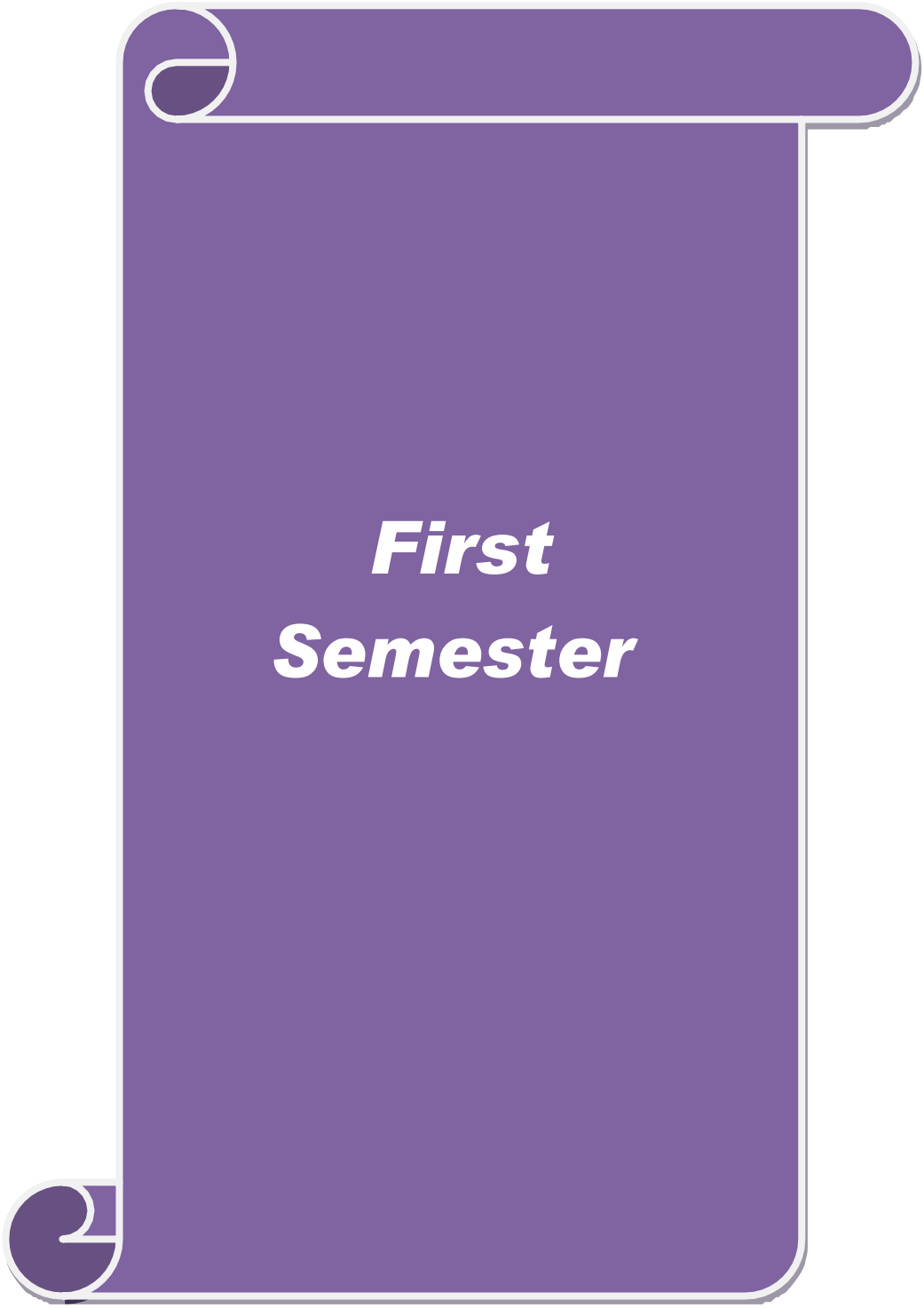
BHARATHIAR UNIVERSITY:: COIMBATORE 641 046

M. Sc. Nanoscience and Technology Curriculum (University Department)

(For the students admitted during the academic year 2023 – 24 onwards)

Course Code	Title of the Course	Credits	Hours		Maximum Marks		
			Theory	Practical	CIA	ESE	Total
FIRST SEMESTER							
13A	Physics of Nanomaterials	4	4	-	25	75	100
13B	Chemistry of Nanomaterials	4	4	-	25	75	100
13C	Biology for Nanotehnology	4	4	-	25	75	100
13D	Properties of Materials	4	4	-	25	75	100
1EA	Computational Methods	4	4	-	25	75	100
1EB	Electronic Devices						
13P	Practical-I	4	-	6	25	75	100
1GS132	Introduction to Nanoscience and Technology	2	2	-	12	38	50
	Total	26	22	6			650
SECOND SEMESTER							
23A	Synthesis of Nanomaterials	4	4	-	25	75	100
23B	Characterization of Nanomaterials	4	4	-	25	75	100
23C	Micro and Nanofabrications	4	4	-	25	75	100
23D	Genetics and Nanobiotechnology	4	4	-	25	75	100
2EA	Nanoelectronics and Nanophotonics	4	4	-	25	75	100
2EB	Nanomagnetic Materials and Devices						
23P	Practical-II	4	-	6	25	75	100
2GS134	Applications of Nanotechnology	2	2	-	12	38	50
	Total	26	22	6			650
THIRD SEMESTER							
33A	Nanotechnology in Health Science	4	4	-	25	75	100
33B	Nanotechnology in Energy Conversion and Storage Devices	4	4	-	25	75	100
33C	Nanosensors and IoT Based Sensors	4	4	-	25	75	100
33D	Advances in Nanobiotechnology	4	4	-	25	75	100
3EA	Environmental Sustainability of Nanomaterials	4	4	-	25	75	100
3EB	Societal Impacts of Nanotechnology						
37V	Summer Internship	2	-	-	50	--	50
33P	Practical-III	4		6	25	75	100
1GS132	Introduction to Nanoscience and Technology	2	2	-	12	38	50
	Total	28	22	6			700
FOURTH SEMESTER							
43A	IPR, Biosafety and Research Ethics	2			12	38	50
47V	Project and Viva-Voce	8			50	150	200
	Total	10					250
	Grand Total	90					2250
ONLINECOURSES							
	Swayam, MOOC Course *etc.*	2	-	-			
VALUE ADDED COURSES							
	Value Added Course – I	2	30	-	50	-	50
	Value Added Course – II	2	30	-	50	-	50
CERTIFICATE COURSES							
	Certificate Course – I	4	30-40	-	100	-	100
	Certificate Course – II	4	30-40	-	100	-	100

The final grading and ranking, only the scholastic courses are counted. However, the award of the degree, the completion of co-scholastic courses is mandatory.


First
Semester

Course code	13A	PHYSICS OF NANOSTRUCTURES	L	T	P	C
Core			4	0	0	4
Pre-requisite		Basic knowledge in general physics and mathematics.	Syllabus Version		2020 - 2021	

Course Objectives:

The main objectives of this course are to:

1. Learn the fundamental physical principles underlying the nanoscale materials.
2. To understand the central concepts and principles in quantum mechanics for small systems.
3. Bridging between macroscopic thermodynamics and microscopic statistical mechanics by using mathematical methods.
4. To learn the fundamental principles underlying and connecting the structure, processing, properties, and performance of materials.

Expected Course Outcomes:

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

1	Understand the physics behind the small systems (Nanomaterials).	K2
2	Apply the quantum mechanical concepts to the multidimensional nanosystems.	K3
3	Understand the concepts of statistical mechanics, chemical kinetics and thermodynamics	K2
4	Understand and evaluate Crystal structure of materials and changes at nanoscale.	K2,K5
5	Understand the fundamental science and engineering principles relevant to materials	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Quantum Mechanics - I	12 hours

Limitations of classical theory - classical and quantum theory of specific heat of solids - wave and particle - Uncertainty principle - Time dependent Schrodinger equation - Time independent Schrodinger equation -Dirac's Notation - Equations of Motion – Schrodinger – Heisenberg - interaction representation.

Unit:2	Quantum Mechanics - II	12 hours

Particle in a box – Infinite potential well - Finite potential well - Quantum mechanical tunnelling - Schrodinger equation for hydrogen atom – Many electron atoms – Chemical bonding – Born Oppenheimer Approximation – Molecular Orbital Theory – Valence bond method.

Unit:3	Statistical Mechanics and Chemical Kinetics	12 hours

Statistical distributions – Rayleigh Jeans law formula and Planck radiation formula for blackbody radiation – Macroscopic states – Microscopic states – Ensembles – Statistical Interpretation of thermodynamic variables – Equipartition Theorem – Chemical equilibrium – Condition for chemical equilibrium – law of mass action – Ionization formula – Dissociation of molecules.

Unit:4	Solid State Physics - I	12 hours

Crystal Structure – Classification of Crystals – Unit Cell – Bravais Lattices – Symmetry in Crystals – Crystal Directions and Crystal Planes – Packing Factor – SCC -BCC -FCC – HCP –

Diamond – Crystal Structure Determination – Bragg's Law – Debye Scherrer Method – Determination of lattice parameters from the powder diffraction method – Laue Method-Bragg's Monochromator-Bragg's Diffractometer-Reciprocal Lattice-Chemical Bonding in Solids-Point Defects-Line Defects-Problems.		
Unit:5	**Solid State Physics – II**	**12 hours**
Free electron theory of metals – Quantum theory of free electrons – Electrons in 3D potential box – Fermi Energy and Density of Free Electron States – Band Theory of Solids – Distinction between metal, semiconductor and insulator based on the band theory – Bloch's Theorem - - Kronig-Penny model for the periodic potential – Brillouin zones – Reduced E versus k curve-Problems		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Quantum Mechanics, G. Aruldhas, Prentice Hall of India, (2010).
2	Fundamentals of Statistical Mechanics by B. B. Laud, New Age International Publishers (2020)
3	Materials Science by G Rangarajan and M S Vijaya, Mc Graw Hill Education (2014).
Book (s) for Reference	
1	A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, Tata McGraw Hill, (2010).
2	Introduction to Solid State Physics, Charles Kittel, 8th Edition, Wiley (2012).
3	Solid State Physics: Structure and Properties of Materials, A.M.Wahab, 2nd Edition, Narosa Publishing house, New Delhi, India, (2007).
4	Solid State Physics, S.O.Pillai, 4th Edition, New Age International Publishers, New Delhi, (2001).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/115/106/115106066/
2	https://nptel.ac.in/courses/122/106/122106034/
3	https://nptel.ac.in/courses/112/105/112105123/
4	https://nptel.ac.in/courses/112/108/112108148/
5	https://nptel.ac.in/courses/115/105/115105099/
6	https://nptel.ac.in/courses/115/104/115104109/

Course Designed by	**Dr N. Ponpandian**	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	M	S	L	L	S	S	S	S
CO2	S	S	M	S	S	M	M	L	S	S
CO3	S	M	M	M	M	S	L	L	L	S
CO4	S	S	M	L	M	M	L	M	M	S
CO5	S	S	S	S	S	L	M	M	L	S
S	Strong			**M**	Medium			**L**	Low	

Course code	13B	CHEMISTRY OF NANOMATERIALS	L	T	P	C
Core			4	0	0	4
Pre-requisite		Should have studied Chemistry/Allied chemistry/Applied chemistry as a major subject during graduate Programme.	Syllabus Version		2020 - 2021	

Course Objectives:

1. To understand the basic concepts of structure of atomic structure
2. To be able to get familiarized with almost all the basic chemistry concepts
3. To lay foundation for material aspects of inorganic chemistry in research and development
4. To enhance the level of understanding of polymer structure and polymer composite
5. Get familiarity with basics of kinetic of chemical reactions.

Expected Course Outcomes:

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

1	Remember the basic of structure of atoms and molecules	K1
2	Understand aromatics and photochemistry of organic molecules	K2
3	Apply d and f block elements for prepare metal chalcogenide	K3
4	Apply polymer composite into differ applications	K3
5	Evaluate suitable organic and inorganic materials for nanomaterial design for solar energy applications	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Chemical Bonds	12 hours

The structural theory of organic chemistry - chemical bonds - the octet rule - writing Lewis structures - exceptions to the octet rule - formula charge – resonance - energy changes - quantum mechanics - atomic and molecular orbitals - The structure of methane sp^3 - The structure of borane sp^2 - The structure of beryllium hydride sp hybridization - Molecular geometry: valence shell electron pair repulsion (VSEPR) theory - Polar covalent - polar and non polar molecules - Representations of organic compounds structural formulas.

Unit:2	Chemical Kinetics	12 hours

Absorption and Adsorption: Mechanism and types - Freundlich and Langmuir adsorption isotherms - multilayer adsorption and BET isotherm (no derivation required) and Applications, factors affecting adsorption of gases on solids and liquids.

Catalysis: Homogenous and heterogenous (Single reactant) - activity and selectivity - enzyme catalysis.

Colloids: Classification, preparation and purification - Colloidal state distinction between true solutions - colloids and suspension = lyophilic - lyophobic multi-molecular - macromolecular and associated colloids - properties and application of colloids - Brownian movement - Coagulation and Schultz-Hardy rule - Zeta potential and Stern double layer (qualitative idea) - Tyndall effect-, and Micelle formation.

Emulsion: Types and properties of emulsions-Emulsifier / Emulsifying agent- Theory of Emulsification-Applications and Uses of Emulsion.

Unit:3	Basics of Photochemistry	12 hours

Theory of light absorption-electronic excitation-properties & energies of excited states-Jablonski diagram-photo physical processes-fluorescence and phosphorescene-excimers and exciplexes-intersystem crossing-energy transfer-geometry of excited states-quantum efficiency. Photochemical reactions of ketones – Norrish Type I, Norrish Type II – Paterno – Buchi reaction, Pericyclic Reactions – Characteristics – Electrocyclic reactions of 1, 3-dienes and 1, 3, 5-trienes.[2+2] and [4+2]cycloadditions. Sigmatropic reactions – [1, 3], [1, 5] and [3, 3] Sigmatropic shifts.

Unit:4	**Transition and Inner Transition Elements**	**12 hours**

Definition and electronic configurations of transition element - General characteristics of transition elements - comparison of first transition series with second and third series elements. Position of lanthanides and actinides in the periodic tables - general characteristics of both series and their comparisons. Basic concepts of coordination compounds- ligands (mono, di, and poly dentate ligand) - chelation - coordination numbers and Nomenclature of coordination compounds. Nature of metal ligand bonding in complex- study by valence bond theory and crystal field theory.

Unit:5	**Chemistry of Polymers**	**12 hours**

Introduction and review of Polymer - Properties of polymers - Polymer additives-plasticizers- fillers and reinforcement- Polymer blends- toughen plastics and phase separated blends - Polymer composites - mechanical properties - Introduction to polymer nanocomposites - Basic materials for polymer nanocomposite - Characterization of polymer nanocomposites - Properties of polymer nanocomposites - Thermoplastic nanocomposites - Thermoset Nanocomposites.

Unit:6	**Contemporary Issues**	**2 hours**

Expert lectures, online seminars – webinars

	Total Lecture hours	**62 hours**

Book (s) for Study

1	Organic Chemistry, T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder, 12th Edition, John Wiley & Sons, New York, 2017.
2	Selected Topics in Inorganic Chemistry, Malik, Wahid U, Tuli G.D, Madan R.D. S. Chand Limited, 2009.
3	Fundamentals of Molecular Spectroscopy, C. N. Banwell, 5thEdition, McGraw Hill Education; 2019.
4	Polymer Science, V.R.Gowariker, N.V. Viswanathan, and Jayadev Sreedhar, New Age International Publishers, 2015.
5	Physical Chemistry, Peter Atkins, Julio de Paula, OUP Oxford, 2010.

Book (s) for Reference

1	Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith, March's 8th Edition, Wiley, 2019.
2	Advanced Inorganic chemistry, F. A. Cotton, G. Wilkinson, C. A. Murilo, M. Bochmann, 6th Edition, Wiley, 2016.
3	Polymer Matrix Composites and Technology, Ru-Min Wang, Shui-Rong Zheng Yujun Zheng, 1st Edition, Woodhead Publishing, 2011.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.youtube.com/watch?v=p_BMWRaL62w
2	https://nptel.ac.in/courses/104/103/104103071/
3	http://nptel.iitm.ac.in
4	https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-cy03/

Course Designed By	**Dr P. Sakthivel**	e-mail	sakthivel.p@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	M	S	M	M	L	S	M
CO2	S	S	L	M	S	L	M	L	S	S
CO3	S	S	L	S	M	L	M	L	M	M
CO4	M	S	S	S	S	M	M	M	M	M
CO5	S	S	L	S	S	M	S	M	M	S
S	Strong			**M**	Medium			**L**	Low	

Course code	13C	BIOLOGY FOR NANOTECHNOLOGY	L	T	P	C
Core			4	0	0	4
Prerequisite		Basic knowledge on Biology or Life Sciences	Syllabus Version		2020 - 2021	

Course Objectives:

1. Explore the fundamental cell science and its growth with respect to prokaryotes and eukaryotes.
2. Know the basic biomolecules and its role in energy generation process.
3. Decipher knowledge on natural defense mechanisms and the techniques involved.

Expected Course Outcomes:

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

1	Remember the elemental concepts behind the cell structure and function	K1
2	Understand the naturally existing bio nanostructures and its assembling process	K2
3	Analyze the ATP generation process via different metabolic pathways	K4
4	Understand the principles of immune mechanisms to combat with non-self-components in the process of self-protection	K2
5	Analyze the interactions of antigen and antibody by immuno techniques	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Basics of Biology	12 hours

Structure and function of cells and organelles in Prokaryotes and Eukaryotes. – Nucleus - chromosome organization, structure and function of genetic material, Ribosomes, Endoplasmic reticulum, Golgi apparatus, Mitochondria, Lysosome and the Plasma membrane. Cell division and Cell Cycle - Mitosis - Meiosis.

Unit:2	Nanostructures in Biological Systems	12 hours

Structure, organization and functions of biomolecules; Carbohydrates – monosaccharides, oligosaccharides and polysaccharides, Proteins – amino acids and its classification, Lipids and Fatty acids – (saturated & unsaturated) and Nucleic acids – structure of DNA and RNA and its types.

Unit:3	Energy Metabolism	12 hours

Energy Metabolism - aerobic respiration and anaerobic respiration - Glycolysis (EMP Pathway), Tricarboxylic acid cycle (TCA), Electron Transport Chain, Substrate level phosphorylation and oxidative phosphorylation - ATP generation, Gluconeogenesis.

Unit:4	Immunology	12 hours

History of immunology, Innate and acquired immunity, Hematopoiesis, Cells and organs of the immune system. B and T- cell activation. Phagocytosis – Oxygen dependent and Oxygen independent killing. Antigen -Properties of antigen. Antibody- structure and types. Hybridoma Technology.

Unit:5	Immunological Reactions	12 hours

Antigen – Antibody Interactions, Complement Pathways – Classical and Alternate

Pathways. Immuno-hematology, Blood group, Rh - incompatibilities. Immuno techniques – ELISA, RIA		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars– webinars Case study: Learn the process of Covid 19 vaccine production and understand the process cum mechanism of antibody production in human body against Coronavirus antigen. Report the importance of vaccination to combat the life threatening diseases.		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	A Text of Microbiology. Revised edition, Dubey RC and Maheswari DK S. Chand and Company Ltd., New Delhi, (2012)
2	Text Book of Microbiology, Ananthanarayan & Paniker's. 9th Edition, Universities Press, (2013).
3	Microbiology, Pelczar TR M J Chan ECS and Kreig N R Tata McGraw-Hill INC., New York, (2006).
Book (s) for Reference	
1	Microbiology, Prescott L M, J P Harley and D A Klein, Sixth edition, International edition, McGraw Hill, (2005).
2	Principles of Biochemistry (IE), Lehninger, David L.Nelson7th Edition, (2017).
3	Kuby Immunology - Richard A Goldsby, Thomas J Kindt. Barbara A Osborne, Fourth edition, W H Freeman and company, New York, (2000).
4	Immunology and Immuno technology, Chakravarthy A R, 1st Edition, Oxford University Press, India. ISBN: 9780195676884, (2006).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.elsevier.com/books/bacterial-physiology-and-metabolism/sokatch/978-1-4832-3137-2
2	https://www.frontiersin.org/journals/microbiology/sections/microbial-physiology-and-metabolism
3	https://www.ncbi.nlm.nih.gov/books/NBK10779/

Course Designed By	**Dr. P. Premasudha**	e-mail	premasudha@buc.edu.in

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	M	S	S	L	S	M	S
CO2	S	S	M	M	S	S	M	S	S	S
CO3	M	L	L	L	M	M	S	S	M	S
CO4	M	M	L	M	S	S	S	S	S	S
CO5	S	S	M	M	S	S	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	13D	PROPERTIES OF MATERIALS	L	T	P	C
Core			4	0	0	4
Pre-requisite		Fundamental knowledge in physics	Syllabus Version		2020 -2021	

Course Objectives:

1. Remember the concepts of atomic bonding, crystal structures, and crystalline nature as related to processing and performance of Chemical materials.
2. Understand the concepts of Imperfection of Crystals between structure-processing-properties for selection of existing materials and development of materials in the structures, and defects.
3. To know about the carrier concentrations in semiconductors, Fermi level concepts, conductivity and mobility concepts of semiconductors, Hall Effect nature - Hall coefficients for intrinsic and extrinsic semiconductors and Hall effect in Semiconductor materials
4. Understand the concepts of Mechanical and Optical properties for given material systems.
5. Understand the concepts of Magnetic properties for given material systems.

Expected Course Outcomes:

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

1	The student will demonstrate a basic remembering of the bonding, structures and nature of the materials.	K1
2	The student will demonstrate an understanding of the properties of materials and defects nature of the materials.	K2,K4
3	The student will demonstrate an understanding of approaches to concepts and mechanism of Materials..	K2,K3
4	The student will demonstrate an understanding of mechanical and optical properties of materials	K2,K4
5	The student will demonstrate an understanding of magnetic properties of materials.	K2,K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Structure of Materials	12 hours

Atomic bonding in solids-binding energy – interatomic spacing – variation in bonding characteristics – Single crystals – polycrystals– Non crystalline solids - Structure models for amorphous materials

Unit:2	Crystal Imperfections	12 hours

Imperfection in solids – Point and line defects-Frenkel defect –Schottky defect-Burger vectors-Vacancies – Interstitials – Dislocations - Generation of dislocation -Geometry of dislocation – Schmid´s law – Surface imperfection – Importance of defects – grain size distribution.

Unit:3	Mechanical and Thermal Properties of Materials	12 hours

Stress – Strain relation- Elastic and plastic deformation-Work hardening – Recrystallization and grain growth

Lattice vibrations, vibrations of simple lattice- phonons, Heat capacity, Thermal expansion - Thermal conductivity

Unit:4	Mechanical And Optical Properties	12 hours

Optical properties – Light interaction with solids – Atomic, electronic interaction, non – radiative transition – refraction, reflection, absorption, transmission, luminescence

Unit:5	**Magnetic Properties**	**12 hours**
Dia and Para-magnetism–ferro, ferri and antiferromagnetism– magnetic hysteresis - Weiss molecular field theory -, Heisenberg's theory – magnetic anisotropy – domain theory - Exchange length –nanomagnetism - superparamagnetism.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study

1	Materials Science and Engineering: An Introduction, W. D. Callister, John Wiley & Sons, (2007).
2	Functional Materials: A Chemist's Perspective, K. Vijayamohanan Pillai and Meera Parthasarathi, Orient Blackswan, (2013).
3	Introduction to Solid State Physics, C. Kittel, Wiley Eastern Ltd, (2005).
4	Materials Science and Engineering: A First Course, V. Raghavan, Prentice Hall, (2006).

Book (s) for Reference

1	Solid State Physics, A.J. Dekker, Macmillan & Co, (2000).
2	Physics of Semiconductor Devices, Michael Shur, Prentice Hall of India, (1995).
3	Introduction to Nanotechnology, Charles P Poole Jr., and Frank J. Ownes, John Wiley Sons, Inc., (2003).
4	"Encyclopedia of Nanoscience &Nanotechnology", H. S. Nalwa (Ed.), American Scientific Publishers, California, (2004).
5	"Introduction to Solid State Physics", C. Kittel, Wiley Eastern Ltd., (2005).

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

1	https://nptel.ac.in/courses/113/104/113104076/

Course Designed By	**Dr C. Viswanathan**	e-mail	viswanathan@buc.edu.in

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	M	L	L	L	L	S
CO2	S	S	M	M	M	L	L	L	M	S
CO3	S	S	M	M	S	L	L	L	S	S
CO4	S	S	S	M	M	L	M	M	M	M
CO5	S	S	S	M	M	L	M	M	M	M

S	Strong		**M**	Medium		**L**	Low

Course code	1EA	COMPUTATIONAL METHODS	L	T	P	C
Elective			4	0	0	4
Pre-requisite		Basic knowledge in Mathematics and Computer programing.	Syllabus Version		2020 -2021	

Course Objectives:

1. To learn about data processing and analysis
2. To gain knowledge on Numerical methods and scientific computing.
3. To understand the Python programming for computation and IOT applications

Expected Course Outcomes:

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

1	Organize, Interpret and analyze data	K4
2	Understand the basic concepts involved in molecular dynamics simulation	K2
3	Understand the basics of data analysis.	
4	Have a knowledge in computational quantum chemistry	
5	Use Python programming for AI, Machine Learning and IOT applications	K3

K1– Remember; **K2**–Undestand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

Unit:1	Biostatistics	12 hours

Definitions – Error – accuracy – precision –bias – Mean – standard deviation – relative standard deviation – coefficient of variation – confident limit of a measurement – propagation of errors – two sided test Vs one sided test – F-test for precision - t-tests for bias – Linear correlation and regression – Analysis of variance (ANOVA).

Unit:2	Root Finding	12 hours

Bisection, Regula-Falsi, Iteration and Newton-Raphson methods (SS), Gauss Jacobi and Gauss Seidal methods.

Unit:3	Numerical Interpolation and Differentiation	12 hours

Newton's forward, backward & general formula for interpolation, Newton's divided difference formula, Lagrange formula (SB); Differentiation: Taylor Series, Runge Kutta Method (RK4) First Order and Simultaneous equation.

Unit:4	Quantum Computation	12 hours

Computational quantum chemistry - Cartesian coordinates and internal coordinates. Calculations using computational software: Geometry optimization, Molecular orbitalHOMO, LUMO), charges, electron density. Importance for frequency calculation, plotting the theoretical vibrational spectra, Interaction energy: BSSE correction.

Unit:5	Python	12 hours

Interpreter- Program Execution - Statements - Expressions - Flow Controls - Functions - Numeric Types - Sequences - Strings - Tuples - Lists - Classes - Constructures - Inheritance - Text & Binary files - Reading and Writing - Visualizing plots

Unit:6	Contemporary Issues	2 hours

Expert lectures, online seminars– webinars

	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Elementary statistical methods, S.P. Gupta, Sultan Chand and sons publishers,(2014).
2	Numerical methods in science and engineering, M.K. Venkataraman, The National Publishing Company –Madras,(1999).
3	Numerical methods with programs in 'C', T. Veerarajan, T. Ramachandran, Tata McGraw Hill, New Delhi,(2006).
4	Numerical Methods, E. Balagurusamy, Tata McGraw Hill Education, 1999.
5	Mark Lutz, "Learning Python", O'Reilly Media, 5th Edition, (2016).
Book (s) for Reference	
1	Python Programming: An Introduction to Computer Science, John M. Zelle
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://onlinecourses.nptel.ac.in/noc19_ee41/preview
2	https://nptel.ac.in/courses/108/106/108106165/
3	https://nptel.ac.in/courses/115/107/115107122/
4	https://nptel.ac.in/courses/106/105/106105166/

Course Designed By	**Dr R. T. Rajendrakumar**	e-mail	rtrkumar@buc.edu.in

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	M	S	M	M	S	S
CO2	M	S	S	S	S	M	L	M	M	S
CO3	S	L	M	M	M	L	L	L	S	S
CO4	M	M	S	M	L	M	M	M	S	S
CO5	S	M	M	L	L	L	L	L	M	S

S	Strong		**M**	Medium		**L**	Low

Course code	1EB	ELECTRONIC DEVICES	L	T	P	C
Elective			4	0	0	4
Pre-requisite		Fundamental knowledge in physics	Syllabus Version		2020 -2021	

Course Objectives:

1. To understand the basics of number systems, digital logic levels, functionality of digital components.
2. Operation of digital electronics circuits.
3. To construct and analyse various digital electronic circuits.

Expected Course Outcomes:

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

1	Understand the concepts of Semiconductor Physics	K4
2	Understand the fundamental concepts and techniques in digital electronics.	K2
3	Understand the basic concepts for advanced electronic devices.	K3
4	Have a knowledge in making diodes and LEDs	K3
5	Have knowledge creation to develop nano and molecular electronic devices.	K4

K1– Remember; **K2**–Undestand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

Unit:1	Semiconductor Physics	12 hours

Electrons and Holes in an Intrinsic Semiconductor – Donor and Acceptor Impurities – Charge Densities in a Semiconductor – The Hall Effect – Conducting Modulation – Generation and Recombination of Charges – Diffusion - - Continuity Equation – Injected Minority Carrier Charge – The Potential Variation within a Graded Semiconductor – Carrier Concentrations in an Intrinsic Semiconductor – Fermi Level in a Semiconductor having Impurities – Band Structure of Open Circuit p-n Junction.

Unit:2	Operational Amplifiers	12 hours

The ideal Op-Amp-inverting, non-inverting and differential amplifiers-CMRR; Op-Amp IC building blocks-emitter coupled differential amplifier, active load, level shifting and output stage; Op-Amp characteristics-open-loop input output characteristics, frequency response and slew rate; Op-Amp applications-adder, subtractor, integrator, differentiator, comparator, voltage-to-current converter, current-to-voltage converter and logarithmic amplifier.

Unit:3	Basic Devices	12 hours

Bipolar Junction Transistor (BJT) – Field Effect Transistor (FET) - Junction Field Effect Transistor (JFET), Metal Oxide Semiconductor Field Effect Transistor (MOSFET) and Metal Semiconductor Junction Field Effect Transistor (MESFET): Structure, Working, I-V Characteristic Studies and its Applications.

Unit:4	Advanced Devices	12 hours

Transfer Electron devices (Gunn Diode) – Principle, Working, I-V Characteristic Studies and Applications - PIN Diode: Structure, Working, - PIN Diode Parameters - PIN Diode as Switches - PIN Diode as Limiters - Photo Detectors – Photo Diode - Light Emitting Diode (LED) – Principle, Construction, Working and Characteristics – Laser - Absorption and Emission of Radiation – Population Inversion – Semiconductor and Diode Lasers.

Unit:5	**Digital Principles**	**12 hours**
Master Slave, J.K, Edge Triggered JK and D-Type Flip Flops – Set up, Hold and Propagation Delay Times - Shift Registers – Counters – Ring Counter – Up Down Counter – Synchronous Counters.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars– webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study

1	Integrated Electronics – Jacob Millman and C. Hal Kias, Tat McGraw Hill Publishing Co. (1971).
2	Basic Electronics (Solid State), B.L. Theraja, S. CHAND (2006).
3	Microwaves, M.L. Sisodia, V.L. Gupta, New Age International (2001).
4	Semiconductor Devices, Kanaan Kano, Prentice Hall of India Pvt. Ltd. (1997)
5	Modern Physics, R. Murugeshan, Ninth Edition (2003).
6	Digital Computer Fundamentals, Thomas C. Bartee, Tata Mc Graw Hill (2011)
7	Optical Electronics, Ajoy Ghatak and K. Thyagarajan, Cambridge University Press (1998)
8	Digital Circuits and Microprocessors, Herbert Taub, McGraw Hill (1982).
9	Text Book of Electronics, S. Chattopadhyay, New Central Book Agency Pvt. Ltd., Kolkata, 2006

Book (s) for Reference

1	Physics of Semiconductor Devices, S. M. Sze and Kwok K. Ng, Wiley Interscience, 3rd Edition (2007).
2	Introduction to Semiconductor Devices, M.S. Tyagi, John Wiley &Sons (2003).
3	Measurement Instrumentation and Experimental Design in Physics and Engineering, M. Saver and A. Man Singh, Prentice Hall, India (2000).

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

1	https://nptel.ac.in/courses/108/108/108108122/
2	https://nptel.ac.in/courses/108/108/108108111/
3	https://nptel.ac.in/courses/108/106/108106069/
4	https://nptel.ac.in/courses/108/105/108105132/

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Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	M	L	L	L	L	S
CO2	S	S	M	M	M	L	L	L	M	S
CO3	S	S	M	M	S	L	L	L	S	S
CO4	S	S	S	M	M	L	M	M	M	M
CO5	S	S	S	M	M	L	M	M	M	M

S	Strong		**M**	Medium		**L**	Low

Course code	13P	PRACTICAL – I	L	T	P	C
Core			0	0	4	4
Pre-requisite		Basic knowledge and understanding in physics, chemistry and biology.	Syllabus Version		2020 - 2021	

Course Objectives:

1. To experimentally realize the concepts in Physics, Chemistry and Biology for nanoscience.
2. To expose students to common topics in Physics, Chemistry and biology to understand nanoscience.

Expected Course Outcomes:

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

1	Gain practical knowledge by applying the experimental methods to correlate with the theory	K4
2	Learn the usage of various measurements.	K2
3	Apply the analytical techniques and graphical analysis to the experimental data	K3
4	Apply the various procedures and techniques for the experiments.	K4
5	Develop intellectual communication skills and discuss the basic principles of scientific concepts in a group.	K4

K1– Remember; **K2**–Understand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

Practical

1	Study the forward and reverse characteristics of a Zener diode
2	Colorimetric titration (acid base, color compound by instrument methods)
3	Pure culture Techniques (i) Spread Plate (ii) Pour Plate (iii) Streak Plate (iv) Serial Dilution
4	Construction of adder, subtractor, differentiator and integrator circuits using the given OP – Amp.
5	Complexometric titration by using EDTA
6	Bacterial Growth Curve and Generation Time
7	Construction of a single FET amplifier with Common Source configuration
8	Potentiometric titration of acid-base
9	Morphology of (i) Bacteria – Gram Staining and (ii) Fungi - Lacto Phenol Cotton Blue Mount
10	DC electrical conductivity and temperature coefficient of resistance of a semiconductor thin film using four point probe
11	Synthesis p-Bromoacetanilide from Acetanilide.
12	Estimation of Carbohydrates
13	Determination of charge type and carrier concentration in a given nanofilms using hall method
14	Preparation of tribromoaniline from Aniline
15	Blood Grouping and Rh Compatibility

Course Designed By	N. Ponpandian	e-mail	ponnpandian@buc.edu.in

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	M	L	S	S	M	S	M	S
CO2	S	M	M	L	S	M	S	L	M	S
CO3	S	M	M	L	S	S	S	M	M	S
CO4	S	M	M	L	S	M	M	S	M	S
CO5	S	M	M	L	S	S	M	M	M	S
S	Strong			**M**	Medium			**L**	Low	

Second Semester

Course code	23A	**SYNTHESIS OF** NANOMATERIALS	L	T	P	C
Core			4	0	0	4
Pre-requisite		Basic knowledge in science (Physics, Chemistry and Biology)	Syllabus Version		2020 - 2021	

Course Objectives:

1. To learn the top-down and bottom-up approach of preparing nanomaterials.
2. To understand the physical, chemical and biological approaches of nanomaterials synthesis.
3. To tune the morphology and functional properties by tuning the preparation parameters.
4. To apply basic knowledge of synthesis to prepare functional and smart materials.
5. To understand the lithographic process for the fabrication of nanodevices.

Expected Course Outcomes:

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

1	Synthesize nanomaterials using physical, chemical and biological approaches	K2
2	Tune the size and shape of the nanomaterials for diverse applications	K4
3	Understand the functionalization of nanoparticles for specific applications	K5
4	Form the nanocomposites for tuning their functional properties.	K5
5	Fabricate the device structures using lithographic techniques.	K6

K1– Remember; K2– Understand; K3– Apply; K4– Analyze; K5– Evaluate; K6– Create

Unit:1	**Chemical Methods**	12 hours

Sol – gel process– Self-assembly process – Electrodeposition – Spray pyrolysis– Flame pyrolysis– Metal nanocrystals by reduction– Solvothermal synthesis– Photochemical synthesis– Sonochemical Synthesis–Reverse micelles and microemulsions– Combustion method–Template process– Chemical vapor deposition(CVD)–Metal organic chemical vapor deposition(MOCVD).

Unit:2	**Physical Methods**	12 hours

Ball milling – Inert gas condensation technique(IGCT)–Thermal evaporation–Pulsed laser deposition(PLD)–DC/RF magnetron sputtering – Molecular beam epitaxy (MBE)–Melt spinning process –IC Fabrication process– Microlithography– Etching – Wet cleaning– CMP–Backend process – Atomic layer deposition (ALD).

Unit:3	**Biological Synthesis**	12 hours

Introduction-Natural nanocomposite materials – Biologically synthesized nanoparticles-Nanostructures and synthetic nanocomposites– Protein based nanostructure formation – DNA Template nanostructure formation- Protein assembly – Biologically inspired nanocomposites– Lyotropic liquid – Crystal templating – Liquid crystal templating of thin films – Block copolymer templating-Colloidal Templating.

Unit:4	**Surface Functionalization of Nanomaterials**	12 hours

Conjugation Chemistry Principles - Amine Reactions - Thiol Reactions - Hydroxyl Reactions - Carboxylic Acid Reactions - Aldehydes and Ketones Reactions - Alkenes and Alkynes - Photochemical Reactions - Biomolecules Conjugation Onto Self-Assembled Monolayers via Covalent Binding - Biomolecules Conjugation on Self - Assembled Monolayers via Affinity Binding - Challenges in (Bio) conjugation.

Unit:5	**Carbon Based Nanomaterials**	12 hours
Synthesis of one-, Two-, Three-, and Zero- dimension Nanostructure and A case study – Carbon nanostructure tuning the size and shape to enhance the functional properties for their potential Applications.		
Unit:6	Contemporary Issues	2 hours
Expert lectures, online seminars – webinars		
	Total Lecture hours	62 hours

Book (s) for Study

1	Advances in the Liquid-phase synthesis of inorganic nanoparticles, Brain L. Cushing, Vladimir L. Kolesnichenko, Charles J. O'Connor, Chem Rev. 104 (2004) 3893-3946.
2	Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer, (2007).
3	Nanotechnology – Enabled Sensors, Kourosh Kalantar – zadeh and Benjamin Fry, Springer, (2008).
4	Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press, (2004).
5	Nanochemistry: A Chemical Approach to Nanomaterials–Royal Society of Chemistry, Cambridge, UK, (2005).

Book (s) for Reference

1	Nanocomposite science and technology, Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, Wiley – VCH Verlag, Weiheim, (2003).
2	Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth - Heinemann Publishers, (1992).
3	Hand book of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press, (2005).
4	Nanochemistry, G.B. Sergeev, Elsevier, (2006).

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

1	https://nptel.ac.in/courses/118/102/118102003/
2	https://nptel.ac.in/courses/118/107/118107015/
3	https://nptel.ac.in/content/syllabus_pdf/118102003.pdf

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Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	S	S	S
CO2	S	S	M	L	S	S	M	S	S	S
CO3	S	S	M	M	S	M	L	M	S	S
CO4	S	S	S	S	S	S	M	S	S	S
CO5	S	S	S	S	S	S	M	M	S	S

S	Strong		M	Medium		L	Low

Course code	23B	**CHARACTERIZATION OF NANO MATERIALS**	L	T	P	C
Core			4	0	0	4
Pre-requisite		Basic knowledge in science (Physics, Chemistry, and Biology)	Syllabus Version		2020 - 2021	

Course Objectives:

1. To provide the students to understand the fundamental principles, concepts pertaining to material characterization
2. To apply for the analysis of structure, optical, mechanical, chemical composition thermal magnetic and electrical properties of the materials.
3. To analyses and apply for designing of new materials with multifunctional properties

Expected Course Outcomes:

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

1	Understand the fundamental concepts and techniques used in material characterization techniques.	K2
2	Familiar in structural and morphological techniques to confirms the phases and surface structure of materials.	K3
3	Analyze the functional properties such as electrical, magnetic, mechanical, optical and thermal properties of materials.	K4
4	Nuclear spectroscopic techniques to identify the chemical environment of the materials.	K5
5	Surface characterization techniques to analyze composition and stoichiometry of the materials.	K5

K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create

Unit:1	**Structural Characterization**	12 hours

Powder X-ray diffractometer - Synchrotron radiation – FTIR spectrometer - Raman Spectrometer - — Stylus profilometer.

Unit:2	**Microscopic and Surface Analysis**	12 hours

Electron microscopes: scanning electron microscope (SEM) – transmission electron microscope (TEM); Scanning Probe Microscopy: atomic force microscope (AFM) – scanning tunnelling microscope(STM); Laser confocal microscope – Brunauer – Emmer – Teller Surface area analysis.

Unit:3	**Spectroscopy**	12 hours

X-ray photoelectron spectroscopy (XPS) – EDAX and WDA - Mass Spectrscopy – Secondary Ion Mass Spectroscopy (SIMS) –ICPMS - Nuclear magnetic resonance (NMR) – Electron spin resonance (ESR).

Unit:4	**Electrical, Mechanical and Magnetic Properties**	12 hours

Impedance Spectroscopy – Electro analytical Techniques: Potentiometry – Cyclic Voltammetry - Physical Property Measurement System (PPMS) –Nanoindentation – Vibrating sample magnetometer.

Unit:5	**Thermal and Optical Properties**	12 hours

Differential scanning calorimeter (DSC) – Thermogravimetric/Diffferential thermal analyzer

(TG/DTA) – UV – Visible spectrophotometer – Spectroflourometer – Contact angle measurement. Dynamic Light Scattering (DLS)		
Unit:6	Contemporary Issues	2 hours
Expert lectures, online seminars – webinars		
	Total Lecture hours	62 hours

Book (s) for Study	
1	Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth-Heinemann Publishers, (1992).
2	Handbook of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press, (2005).
3	Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press, (2004).
4	Nanotechnology - Enabled Sensors, Kourosh Kalantar-zadeh and Benjamin Fry, Springer (2008).
5	Nanochemistry, G. B. Sergeev, Elsevier, (2006).
Book (s) for Reference	
1	Nanotechnology: Basic Science and Emerging Technologies – Mick Wilson, 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, Weinheim, (2003).
3	Introduction to Nanoscience, S. M. Lindsay, 1st Edition, Oxford University Press, (2010).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/118/104/118104008/
2	https://nptel.ac.in/courses/113/107/113107081/
3	https://www.classcentral.com/course/swayam-structural-analysis-of-nanomaterials-14310

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Mapping with Programme Outcomes										
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	M	S	S	S	S	S	S
CO2	M	S	S	M	S	S	S	S	S	S
CO3	M	S	S	L	S	S	M	S	M	S
CO4	M	S	S	M	S	S	M	S	M	S
CO5	M	S	S	M	S	S	M	S	S	S

S	Strong		M	Medium		L	Low

Course Code	23C	MICRO AND NANOFABRICATIONS	L	T	P	C
Core			4	0	0	4
Pre-requisite		Basic understanding in Materials Science	Syllabus Version		2020 - 2021	

Course Objectives:

1. To understand the clean room standards and other aspects on process integration.
2. To understand various techniques involved in nanostructuring MEMS/NEMS.
3. To understand the process of nano manipulation and analyzing it by various imaging techniques.
4. To understand the fundamentals of mems design, application and future challenges.
5. To understand the fundamentals of NEMS design, application and future challenges.

Expected Course Outcomes:

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

1	The student will get a basic understanding on clean room standards and process integration.	K2
2	The student will demonstrate an understanding on nanostructuring by various lithographic techniques.	K2,K6
3	The student will be able to image and inspect nanostructured materials by various conventional and advanced techniques.	K2,K4
4	The student will understand the MEMS techniques, application and its future	K4,K5
5	The student will understand the NEMS techniques, application and its future	K4,K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Clean Room and Process Integration	12 hours

Clean Rooms: Cleanroom Standards – Clean room sub-systems – Environment Safety and Health Aspects – Oxidation — Ion Implantation – Etching- Diffusion Process Integration: Junction and Oxide Isolation – LOCOS methods – Trench Isolation – Semi Insulating Substrates -Schottky contacts Implanted Ohmic Contacts – Alloyed Contacts – Multi level Metallization.

Unit:2	Nanostructuring By Physical Techniques	12 hours

Introduction–Lithography–Photolithography – Phase-shifting photolithography – Electron beam lithography-X – ray lithography – Focused ion beam (FIB) lithography – Neutral atomic beam lithography – Nanomanipulation and nanolithography– Soft Lithography– Assembly of Nanoparticles and nanowires - Other methods for microfabrication.

Unit:3	Nanomanipulation and Processing	12 hours

Scanning tunneling microscopy (STM) – Atomic force microscopy (AFM) – Near-field scanning optical microscopy (NSOM) – Advanced Techniques: Embossing and surface passivation, Dimensional Subtraction and Addition, Multistep Processing, of –Micro contact printing– Molding – implications and applications of the conventional and advanced techniques.

Unit:4	MEMS Techniques and Application	12 hours

MEMS materials-MEMS challenges - scaling - scaling in geometry, rigid body dynamics, electrostatic forces, electromagnetic forces, electricity, fluid mechanics, heat transfer. Need for MEMS-MEMS features-MEMS design limits and safety factors - MEMS future and applications, microsystems and microelectronics-Recent trends in MEMS.

Unit:5	NEMS Techniques and Applications	12 hours

Introduction to NEMS and its architecture - carbon nanotube electronics - modeling - analysis and simulation - simulation of Actuators, FET, Pressure transducer - applications and future challenges.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Nanostructures & Nanomaterials Synthesis, Properties Applications, Guozhong Cao, World Scientific Publishing Private Ltd., (2004).
2	Nanofabrication, Principles, Capabilities and Limits, Zheng Cui, Springer Science business media, (2008).
3	MEMS and NEMS systems, Devices and Structures‖, Syergey Edward Lyshevski, CRC Press, New York, (2002).
4	MEMS and Microsystems Design and Manufacture, Tai Ran Hsu, Tata Mcraw Hill, (2002).
5	Micro Electro Mechanical System Design, James J Allen, CRC Press-Taylor & Francis‖, New York, (2005).
6	Micro and Smart Systems‖, Ananthasuresh G. K, Vinoy. K.J, Gopalakrishnan.S, Wiley India Pvt Ltd, New Delhi, (2012).
Book (s) for Reference	
1	Foundations of MEMS, Chang Liu, Pearson education India limited, (2006).
2	MEMS, Mahalik N P, Tata McGraw-Hill Education, (2008).
3	Marc. J, Madou, "Fundamentals of Microfabrication: The Science of Miniaturization", CRC Press, (2002).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/117/105/117105082/
2	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.111.3275&rep=rep1&type=pdf

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Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	L	M	S	S	L	L	L	M
CO2	S	S	S	S	S	M	M	L	S	S
CO3	S	S	S	M	S	S	M	L	S	S
CO4	S	S	M	S	M	L	S	S	S	S
CO5	S	S	M	S	M	L	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	23D	GENETICS AND NANOBIOTECHNOLOGY	L	T	P	C
Core			4	0	0	4
Prerequisite		Basic knowledge on Biology and Nanotechnology	Syllabus Version		2020 -2021	

Course Objectives:

1. Study the central concepts of Molecular biology
2. Decipher the knowledge on nanoparticle inaction with cell membrane
3. Know how to probe the nanoparticles inside the cell with developed techniques

Expected Course Outcomes:

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

1	Remember the central dogma of cell survival	K2
2	Understand the process of transcription and its enzymology	K2
3	Understand the concept of triplet codon and its genetic importance in bringing up protein structure	K2
4	Analyses the process of nanoparticle internalization inside the cell the structures	K4
5	Evaluate the process and interactions of nanoparticles with in the cellular structures	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Molecular Biology	12 hours

Chromosomes and its structure, structure and types of DNA – Double helix, nucleotides, DNA replication, semiconservative replication, DNA polymerase, replication process, mutagenesis and types of mutagenesis, difference between mutation and mutagenesis, mutagenesis techniques. DNA repair – base excision repair, nucleotide excision repair, mismatched repair.

Unit:2	Transcription	12 hours

RNA – Definition, structure of r-RNA, t-RNA and m-RNA. Initiation of transcription in prokaryotes, prokaryotic RNA polymerase, prokaryotic promoters, elongation, and termination in prokaryotes, prokaryotic termination signals. Reverse transcription.

Unit:3	Translation	12 hours

Protein synthesis (Translation) - Basic mechanism of Protein synthesis: Initiation, elongation, termination, Protein Targeting, Folding, and Modification process - Gene expression: Prokaryotic and Eukaryotic gene expression, Regulation of gene expression - genetic code, ribosome structure, DNA repairing of Genetic code.

Unit:4	Cell Membrane Interactions and Intracellular Trafficking of Nanoparticles in Cell	12 hours

Phagocytosis, Clathrin-mediated endocytosis (CME), Caveolae-dependent endocytosis, Clathrin /caveolae independent endocytosis, Macropinocytosis. Cell organelles like Endoplasmic reticulum, Golgi bodies and lysosomes.

Unit:5	Probing Cellular Interactions of Nanoparticles	12 hours

Confocal laser scanning microscopy, Flow cytometry, ICP-MS, Western blotting, PCR and RT

– PCR		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Molecular cell biology, Darnell, Lodish, Baltimore, Scientific American Books, Inc., (1994).
2	Microbial Genetics, Freifelder, D., 2nd Ed. Narosa Publishing House, New Delhi, (2006).
3	Handbook of Biomedical Instrumentation – R.S. Khandpur, Tata McGraw Hill, (2003).
Book (s) for Reference	
1	Microbiology, Prescott L M, J P Harley and D A Klein, 6th edition, International edition, McGraw Hill, (2005).
2	Microbial Genetics, Maloy, S.R., Cronan, J.E. Jr. and Freifelider, D. 2ndEd. Jones and Bartlett Publishers, (1994).
3	Molecular cell biology, Darnell, Lodish, Baltimore, Scientific American Books, Inc., (1994).
4	Pricinciples of Gene Manipulation, Primrose. S.B., Twyman R.M., Old. R.W. Blackwell Science Limited, (2001).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://dx.doi.org/10.3762%2Fbjnano.11.25
2	https://www.ncbi.nlm.nih.gov/books/NBK10779/
3	https://nptel.ac.in/courses/102/107/102107058/
4	https://nptel.ac.in/courses/118/106/118106019/

Course Designed By	**Dr P. Premasudha**	e-mail	premasudha@buc.edu.in

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	M	L	S	S	L	S	S	S
CO2	M	S	L	M	M	M	M	L	S	S
CO3	S	S	L	L	M	S	S	S	S	S
CO4	S	M	M	S	S	S	S	S	S	S
CO5	S	S	S	S	S	S	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	2EA	NANOELECTRONICS AND NANOPHOTONICS	L	T	P	C
Elective			4	0	0	4
Pre-requisite		Basic Physics Concepts	Syllabus Version		2020 -2021	

Course Objectives:

The main objectives of this course are to:

1. The rapid growth of the integrated circuit (IC) industry has led to the emergence of nano microelectronics process engineering as a new advanced discipline. Thus, there is a need to impart quality education at a sufficiently advanced level in the current state of art Nano electronics and design discipline.
2. It provides an advanced level vast understanding to the device electronics for integrated circuits, a foundation for the device fabrication and various application in the field of sensors technology, optoelectronics, communication and nanotechnology etc.

Expected Course Outcomes:

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

1	Develop an appreciation for the conceptual foundations underlying the operation of nanoelectronic devices.	K4
2	Understand the diverse electronic device fabrication.	K2
3	Practical understanding of engineering concepts and demonstrate application to get the academic and industrial jobs.	K6
4	Interact scientifically with industry both within and outside of a classroom setting.	K6
5	Develop an appreciation of continuing educational and professional development.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Basics of Nanoelectronics	12 hours

Physical Fundamentals: Electromagnetic fields and photons – Quantization of action - Charge and flux – Electrons behaving as waves (Schrodinger equation) – Electrons in potential wells – Photons interacting with electrons in solids – Diffusion process - Quantum Computers.

Unit:2	Quantum Electronics	12 hours

Quantum electronic devices - From classical to quantum physics -Upcoming electronic devices – Electrons in mesoscopic structure – Short channel MOS transistor – Split gate transistor – Electron wave transistor – Electron spin transistor – Quantum cellular automate (QCA) – Quantum dot array – Principles of single electron transistor (SET) – SET circuit design – comparison between FET and SET circuit design.

Unit:3	Nanoelectronic Devices and Applications	12 hours

Nanoelectronics with tunneling devices - Super conducting devices – Tunneling element technology - RTD – Circuit design based RTD –Defect tolerant circuits, Molecular electronics - Elementary circuits – Flux quantum devices – Applications of super conducting devices.

Memory devices and sensors – Nano ferroelectrics - ferroelectric random access memories – introduction – Fe RAM circuit design – ferroelectric thin film properties and integration — surface and bulk acoustic devices – gas-sensitive FETs – resistive semiconductor gas sensors – electronic noses – identification of hazardous solvents and gases – semiconductor sensor array.

Unit:4	**Nanophotonics**	**12 hours**

Electromagnetic properties of nanostructures – Wavelength and dispersion laws – Density of states– Maxwell and Helmholtz equations – **Photonic Crystals – Definition and types of photonic crystals -** Photonic band-structure and photonic band gap - Propagation of light in periodic media – Brillouin zones - Band structure in periodic media – 1D case. **Fabrication of photonic crystals -** Photonic crystals by self-assembly - Photonic crystals by microfabrication - Photonic crystals with tunable properties.

Unit:5	**Biophotonics**	**12 hours**

Interaction of Light with cells and tissues - Nature of optical interactions (optical loss and optical transparency) - Optical properties of a tissue (Double integrating sphere experiment) – Light-induced processes in tissues – Autofluorescence, photochemical processes, thermal effects, photoablation, plasma induced ablation and photo disruption. Bioimaging –Biosensing – Up-conversion nanoparticles. Bioderived materials (Baceriorhodopsin, Green fluorescent protein, DNA, Bio-objects and bio-colloids) – Bioinspired materials – Biotemplates (Bacteria and Viruses as templates).

Unit:6	**Contemporary Issues**	**2 hours**

Expert lectures, online seminars – webinars

	Total Lecture hours	**62 hours**

Book (s) for Study

1	Nanoelectronics and Nanosystems: from Transistors to Molecular Devices. K.Goser, P. Glosekotter, J. Dienstuhl, Springer, (2004).
2	Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices (2nd edition), Rainer Waser (Ed.), Wiley-VCH Verlag, Weiheim (2005).
3	Introduction to Nanophotonics, Sergey V. Gaponenko, Cambridge University Press, New York, ISBN-13 978-0-521-76375-2 (2010).
4	Photonic crystals: Physics and Technology, (Eds.) C. Sibilia, T. M. Benson, M. Marciniak, T. Szoplik, (ISBN: 978-88-470-0843-4) (2008).
5	Introduction to Biophotonics, Paras N. Prasad, (John Wiley and Sons, New Jersey), ISBN: 0-471-28770-9 (2003).

Book (s) for Reference

1	Nano and Molecular Electronics Handbook, Edited by Sergey Edward Lyshevski, CRC Press, (2007).

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

1	https://nptel.ac.in/courses/117/108/117108047/
2	https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-701-introduction-to-nanoelectronics-spring-2010/readings/MIT6_701S10_notes.pdf
3	https://nptel.ac.in/courses/118/106/118106021/

Course Designed By:	**Dr. N. Ponpandian**	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	M	S	S	S
CO2	S	M	S	S	M	M	M	S	S	S
CO3	S	M	S	M	S	S	S	S	S	S
CO4	S	L	M	S	S	S	S	S	S	S
CO5	S	M	S	M	M	S	S	S	S	S
S	Strong			**M**	Medium			**L**	Low	

Course code	2EB	NANOMAGNETIC MATERIALS AND DEVICES	L	T	P	C
Elective			4	0	0	4
Pre-requisite		Basic understanding in Physics.	Syllabus Version		2020 -2021	

Course Objectives:

The main objectives of this course are to:

1. To understand the basic magnetic parameters and the importance of property structure relations in determining the absolute value of these parameters.
2. To understand the magneto-transport in nanoscale systems.
3. To provide a knowledge of basic mechanisms for tuning the magnetic properties

Expected Course Outcomes:

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

1	Gain in-depth knowledge in the concepts of magnetism at both micro and nanoscale.	K4
2	Gain good knowledge in nanomagnetism and the advanced tools to study.	K2
3	Understanding the various imaging techniques to study the magnetic behaviors.	K6
4	Identity the suitable applications of the magnetic materials based on the functional properties.	K6
5	Apply the knowledge to make various applications of nanomagnetic in data storage and biomedicine.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Fundamental s of Magnetism	12 hours

Magnetic fundamentals –Antiferromagnetic materials – Domains and the magnetization process– Coercivity of fine particles – Super paramagnetism in fine particles – Exchange anisotropy - Induced anisotropy in thin films – Electron transport in magnetic multi-layers – Spin polarized electron tunneling – Interlayer exchange coupling – Spin relaxation in magnetic metallic layers and multi-layers - Nonequilibrium spin dynamics in laterally defined magnetic structures.

Unit:2	Nanomagnetism	12 hours

Two-spin channel model - Two terminal spin electronics – Three terminal spin electronics - Spin tunneling - Study of ferromagnetic and antiferromagnet interfaces – Photoemission Electron Microscopy - X-ray Absorption Spectroscopy - X-ray Magnetic Linear Dichroism (XMLD) - X-ray Magnetic Circular Dichroism (XMCD) - Temperature dependence of X-ray Magnetic Dichroism

Unit:3	Fabrication and Imaging	12 hours

Molecular nanomagnets – Mesoscopic magnetism - Particulate nanomagnets – Geometrical nanomagnets – Fabrication techniques scaling – Characterization using various techniques – Imaging magnetic microspectroscopy – Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy.

Unit:4	Magnetic Data Storage and Recording	12 hours

Magnetic data storage – Disk formatting – Partitioning – Hard disk features – Hard disk data

transfer modes – Programmed I/O – Direct memory access – Ultra DMA – Data addressing – Standard CHS addressing – Extended CHS addressing – Logical Block Addressing – Magnetic recording- Principles of magnetic recording - Magnetic digital recording - Perpendicular recording - Magneto-Optic recording - Magnetic media – Kerr effect – Faraday effect.		
Unit:5	**Magnetic Structures and Application**	**12 hours**
Magnetic sensors and Giant Magnetoresistance - Optically transparent materials - Soft ferrites- Nanocomposite magnets - Magnetic refrigerant – Ferro/biofluids– Biomedical applications of magnetic nanoparticles - Diagnostic applications - Therapeutic applications - Physiological aspects - Toxic effects.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Hans .P.O, and Hopster. H, "Magnetic Microscopy of Nanostructures", Springer, 2004.
2	Bland. J.A.C, and B. Heinrich. B, "Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism", Springer, 2004.
3	Nicola. A.S, "Magnetic Materials: Fundamentals and Device Applications", Cambridge University Press, 2003.
Book (s) for Reference	
1	J. M. D. Coey, Magnetism and Magnetic Materials, Pearson Education, 2010.
2	B. D. Cullity, C. D. Graham, Introduction to Magnetic Materials, John Wiley & Sons, Inc, 2009.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://www.youtube.com/watch?v=QQZ6EGf0Ju8
2	https://nptel.ac.in/courses/115/106/115106061/
3	https://nptel.ac.in/courses/115/103/115103038/

Course Designed By:	**Dr. N. Ponpandian**	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	M	S	S	S
CO2	S	M	S	S	M	M	M	S	S	S
CO3	S	M	S	M	S	S	S	S	S	S
CO4	S	L	M	S	S	S	S	S	S	S
CO5	S	M	S	M	M	S	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	23P	PRACTICAL – II – SYNTHESIS AND CHARACTERZATION OF NANAMATERIALS	L	T	P	C
Core			0	0	4	4
Pre-requisite		Basic knowledge and understanding in Nanoscience.	Syllabus Version		2020 -2021	

Course Objectives:

Students get to know the meaning of the "nano" in correlation to materials – they understand the meaning of their size in comparison to bulk materials, atoms and molecules. They learn about specific phsyco-chemical properties of nanomaterials and related applications. They learn basic physical techniques and chemical synthesis methods for the preparation of nanomaterials, and basic procedures for surface functionalization and coating of nanomaterials. They get an insight into characterization methods for nanomaterials.

Expected Course Outcomes:

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

1	Understand the meaning of the expression nanomaterials in comparison to bulk materials, atoms and molecules	K4
2	Basic knowledge on physical and chemical procedures for the fabrication and synthesis of nanomaterials	K2
3	Knowledge of the characterization methods of nanomaterials, the limitations related to their size and interpretation of the results	
4	Knowledge of basic surface functionalization and coating procedures for nanomaterials	K3
5	Knowledge on interparticle interactions and assembly of nanoparticles into complex structures/materials	

K1– Remember; **K2**–Understand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

Practical

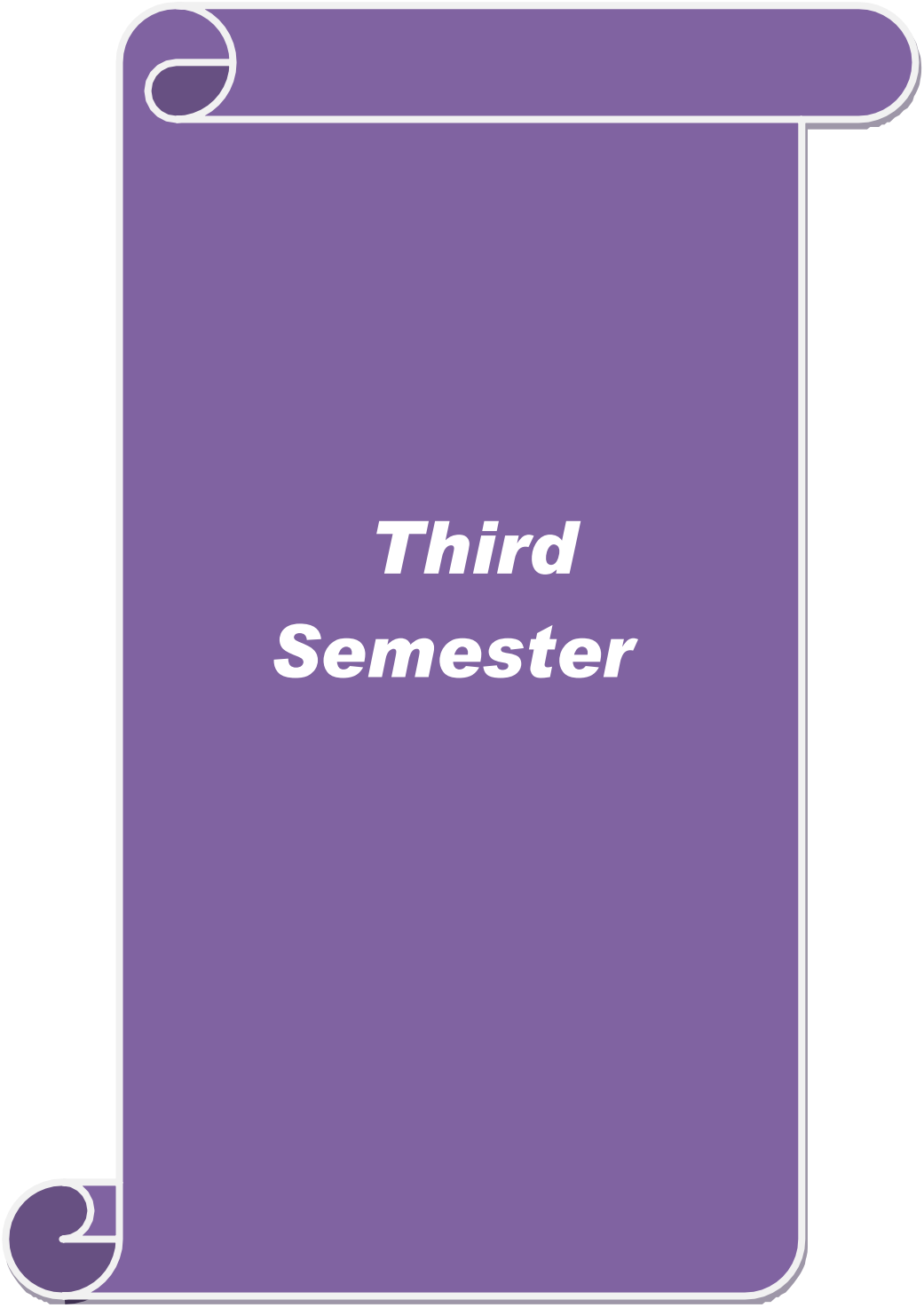
1	Synthesis of Au/Ag nanoparticles using co-precipitation method,
2	Synthesis of CdS nanoparticle using hydrothermal process.
3	Synthesis of ZnO nanoparticles using sputtering process.
4	Synthesis of TiO_2 nanoparticles using sol-gel process.
5	Synthesis of Fe_2O_3nanofibres using electrospinning
6	Preparation of WO_3 nanostructures using microwave synthesis.
7	To optimize the concentration of nanoparticles dispersed solution using UV-vis spectroscopy.
8	Fabrication of porous alumina or anodized alumina template.
9	To find the optical band gap of the given semiconducting materials by measuring UV-Visible transmission spectrum.
10	To find the average grain/crystallite size, unit cell parameters, microstrain by recording the X-ray diffraction pattern of the given sample.
11	Isolation of chromosomal DNA from microbes
12	Fractionation and Size Determination of nucleic acids and proteins – (i) Agarose Gel Electrophoresis and (ii) SDS – PAGE Electrophoresis
13	Estimation of Protein – Bardford Method

14	Separation Techniques: Chromatography (i) TLC and (ii) Column
15	Antibiotic Susceptibility Test - Kirby Bauer Technique

Course Designed By	N. Ponpandian	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	M	S	S	S	S	S	S
CO2	S	S	L	L	S	S	S	S	S	S
CO3	S	S	S	M	S	M	S	S	S	S
CO4	S	S	S	S	S	L	S	S	S	S
CO5	S	S	S	S	S	M	S	S	S	S

S	Strong		**M**	Medium		**L**	Low


Third
Semester

Course Code	33A	NANOTECHNOLOGY IN HEALTH SCIENCE	L	T	P	C
Core			4	0	0	4
Pre-requisite		This course requires basic knowledge in material Physics, Chemistry and Biotechnology to understand the diverse nature of nanomaterials and their applications.	Syllabus Version		2020 -2021	

Course Objectives:

1. The course provides over view of the distinctive features of nanotechnology and their application to health science and technology. It includes active participation of student in class room through in-depth discussion sessions, presentation and a group projects.
2. Aim to cater students from different disciplines to understand the interdisciplinary nature of science.
3. Aims to provide knowledge and recent development in nanotechnology in regenerative medicine.

Expected Course Outcomes:

On completion of the course the student should able to:

1	Understand the concepts begin usage of nanomaterials in health science.	K3
2	Describe structure and function of nanomaterials.	K3
3	Understand and account for the design strategies and nano-scale phenomenon nanomedicine	K4
4	Explain strategies behind drug development and its mode of action	K5
5	Understand and describe the design and function of nano-carriers for drug and gene delivery	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Basics of Biomaterial Science	12 hours

Introduction of biomaterials science-Definition and classification of biomaterials-metals, ceramics, polymers and nanocomposites-Properties of biomaterials (Physical-Chemical-Biological-Mechanical-Electrochemical properties) - Nano-scale phenomena in biomaterials-Smart gels and their properties.

Unit:2	Materials for Bone and Dentistry	12 hours

Materials in Orthopedics: Structure and composition of bone- Conventional materials for orthopedics-Orthopedic nanomaterials-Biological properties of bone grafts-Alloplastic materials-Bone stabilizers-Artificial implant devices-Implant failure.

Dental materials: Dental anatomy-Characteristics of oral environment - Classification of dental restorative materials - Bonding agents-Principles of adhesion-Resins-Dental ceramics-Cements-Glass ionomers-Dental implant devices.

Unit:3	Nanobiomaterials and Tissue Engineering	12 hours

Principles of tissue engineering-Hard and soft tissue engineering-Nanobiomaterials for artificial cells-Scaffolds for tissue engineering-Materials-Fabrication techniques-Synthetic matrices for bladder reconstruction; Nanoparticles-Magnetic nano beats-Artificial skin; Composite grafts-Skin substitutes-Construction of small blood vessel; Production of retrovirus-Collagen gel scaffolds-Silicone materials; Breast and genital implants.

Unit:4	Basics of Nanomedicines	12 hours

Concept of nanomedicines-Rationale for designing of nanomedicines-Nano-structures in nanomedicines-transport of nanoparticles across the biological barriers, parameters affecting binding and uptake of nanoparticles-size, shape, surface charge, protein corona, surface modification-Clinical translation of nanomedicines: Preclinical and clinical considerations of

nanomedicines-Regulation of nanomedicines.		
Unit:5	**Regenerative Medicine**	**12 hours**
Introduction to regenerative medicine-Methods of cell based therapy-Stem cells-Molecular and cellular based of organ development-Therapeutic uses of stem cells-Molecular bases of disease-Bio-artificial organs; Artificial pancreas-Lever-Ear-Heart-Ethics-Current issues in patent law-From concept to market (Regenerative products).		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Book(s) for Study	
1	Biomaterial science an introduction to materials in medicine, Buddy D. Ratner, Allans S. Hoffman, Frederick J. Schoen, Jack E. Lemons, **2004, ISBN: 0-12-582463-7.**
2	Biomechanics and Biomaterials in Orthopedics, Dominique G. Poitout, 2nd edition, Springer, **2004, ISBN: 978-1-84882-663-2.**
3	Advanced Dental Biomaterials, Zohaib Khurshid Shariq Najeeb Muhammad Sohail Zafar Farshid Sefat, 1st edition, 2019, **ISBN: 9780081024768.**
4	Nanobiomaterials in Hard Tissue Engineering, Alexandru Mihai Grumezescu, Volume 4, **2016, ISBN: 9780323428620.**
5	Stem Cells & Regenerative Medicine, Audet, Julie, Stanford, William L, Springer Publications, **2009, ISBN: 978-1-59745-060-7.**
6	Tissue engineering, second edition, Hansjorg Hauser, |Martin Fussenegger, **2007**, **ISBN: 978-81-8489-248-2**
7	Principles of Regenerative Medicine, Anthony Atala, Robert Lanza, Tony Mikos, Robert Nerem, 3rd edition, **2018**, **ISBN: 9780128098806.**
Book (s) for Reference	
1	Biomaterials, Sujata V. Bhat, Alpha Science International, **2005, ISBN: 1842652079**.
2	Materials for Biomedical Engineering: Nanobiomaterials in Tissue Engineering Kindle, Alina Maria Holban, Alexandru Grumezescu, 1st edition, **2019, ISBN: 0128169095.**
3	Basic Dental Materials, Manappallil John, 4th edition, **2016, ISBN: 10-9789352500482.**
4	Nanobiomaterials in Soft Tissue Engineering, Alexandru Mihai Grumezescu, Volume 4, **2016, 978-0-323-42865-1.**
5	The Clinical Nanomedicine Handbook, By Sara Brenner, CRC Press, **2017, ISBN: 1439834792**.
6	Foundation of Regenerative Medicine, Anthony Atala, 1rd edition, **2009, ISBN: 9780123785626.**
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://ocw.mit.edu
2	https://chalmers.instructure.com
3	https://www.mooc-list.com
4	https://www.classcentral.com

Course Designed By	**Dr A.M. Ballamuragan**	e-mail	balamurugan@buc.edu.in

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	L	S	S	M	L	S	S	M
CO2	S	S	M	S	S	S	M	S	S	M
CO3	S	S	M	M	S	M	S	S	M	S
CO4	S	S	L	S	M	S	S	S	M	L
CO5	S	M	M	M	S	S	S	S	S	M
S	Strong			**M**	Medium			**L**	Low	

Course code	33B	NANOTECHNOLOGY FOR ENERGY CONVERSION AND STORAGE DEVICES	L	T	P	C
Core			4	0	0	4
Pre-requisite		Physics/Chemistry/Nanoscience/Allied chemistry/Applied Chemistry as a Major Subject During Graduate Programme.	Syllabus Version		2020 -2021	

Course Objectives:

1. To understand the basic concepts of energy systems
2. Study the fundamental concepts of energy conversion systems
3. To learning the different energy storage methods
4. Different semiconducting materials introduced to the students

Expected Course Outcomes:

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

1	Remember the basic concepts of energy conversion systems	K1
2	Appraise the working of fuel cells	K3
3	Understand the photovoltaic cells	K2
4	Demonstrate the working of Solar cells	K4
5	Appraise the oxides of semiconductor materials for green energy device	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Fundamental Concepts in Electrochemistry	12 hours

Electrochemical Cell - Faraday's laws - Electrode Potentials - Thermodynamics of electrochemical cells - Polarization losses in electrochemical cells - Electrode process and kinetics, Electrical double layer - Photoelectrochemical cell - thermoelectric effect.

Unit:2	Energy Conversion Systems	12 hours

Issues and Challenges of functional Nanostructured Materials for electrochemical Energy - Conversion Systems - Fuel Cells - Principles and nanomaterials design for; Proton exchange membrane fuel cells (PEMFC) - Direct methanol fuel cells (DMFC) - Solid-oxide fuel cells (SOFC) - Current status and future trends.

Unit:3	Photovoltaic Systems	12 hours

Principles of photovoltaic energy conversion (PV) - Types of photovoltaic Cells - Physics of photovoltaic cells - Organic photovoltaic cell cells - thin-film Dye-Sensitized Solar Cells - Quantum dot (QD) - Sensitized Solar Cells (QD-SSC) - Organic-Inorganic Hybrid Bulk Heterojunction (BHJ-SC) Solar cells - Current status and future trends.

Unit:4	Energy Storage System - Batteries	12 hours

Energy Storage Devices - Primary and Secondary Batteries (Lithium-ion Batteries) - Cathode and anode materials - Nanostructured Carbon-based materials – Nano - Oxides - Novel hybrid electrode materials - Current status and future trends.

Unit:5	Electrochemical Capacitors	12 hours

Capacitor - Electrochemical supercapacitors - electrical double layer model - Principles and materials design - Nanostructured Carbon-based materials - Redox capacitor Nano oxides - Conducting polymers based materials- Current status and future trends.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars– webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study

1	Allen J.Bard and Larry R Electrochemical methods: Fundamentals and Applications, Faulkner, 2nd Edition John Wiley & Sons. Inc, (2004).
2	D. Linden. Thomas B. Reddy, Handbook of Batteries, 3rd Edition, McGraw-Hill, New York, (2002).
3	B.E. Conway, Electrochemical supercapacitors: Scientific Fundamentals and Technological Applications, Kluwer Academic Plenum publisher, New York, (1999).
4	C. Brabec, V. Dyakonov, U. Scherf, Organic Photovoltaics: Materials, Device Physics, and Manufacturing Technology, 2nd Edition, Wiley VCH, (2014).
5	J. Larmine and A. Dicks, Fuel Cell System Explained, John Wiley, New York, (2000).

Book (s) for Reference

1	Science and Technology of Lithium Batteries-Materials Aspects: An Overview, A. Manthiram, Kulwer Academic Publisher, (2000).
2	M. S. Whittingham, A. J. Jacobson, Intercalation Chemistry, Academic Press, New York, (1982).
3	M. Wakihara, O. Yamamoto, (Eds.) Lithium Ion Batteries: Fundamentals and Performance, Wiley –VCH, Weinheim, (1998).

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

1	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ch26/
2	https://nptel.ac.in/courses/112/107/112107283/
3	https://nptel.ac.in/courses/102/107/102107058/

Course Designed By	**Dr P. Sakthivel**	e-mail	sakthivel.p@buc.edu.in

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	M	L	S	L	S	S
CO2	S	M	M	L	L	M	S	M	S	S
CO3	S	L	M	L	S	M	S	M	S	S
CO4	S	M	L	S	L	M	S	L	S	S
CO5	S	M	M	S	S	M	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	33C	NANOSENSORS AND IoT BASED SENSORS	L	T	P	C
Core			4	0	0	4
Pre-requisite		Basic knowledge in nanomaterials, sensors and internet.	Syllabus Version		2020 - 2021	

Course Objectives:

1. Understand the basic transduction principles and parameters and characteristics of sensors
2. Gain insights on the components, fabrication and operation of the Physio-chemo-bio nanosensors.
3. Identify suitable sensors suitable for various applications.
4. Evaluate the figures of merits of a nanosensor.
5. Use Internet of Things (IOT) to enable combination of nanosensors for real world applications.

Expected Course Outcomes:

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

1	Identify and understand the various components of nanosensors and their characteristics.	K2
2	Use various nanostructured materials for the fabrication of nanosensors for various applications.	K3
3	Examine or evaluate the performance parameters of the nanosensors.	K4
4	Develop smart and remote assessable nanosensors by combining Internet of Things .	K6
5	Improve the sensor properties by tuning the functional properties of the materials.	

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Sensor Principles	12 hours

Active and passive sensors - static characteristic - accuracy, error, precision, resolution, sensitivity, selectivity, noise, drift, detection limit - reproducibility, hysteresis, stability, response time, recovery time, dynamic range - dynamic characteristics - zero order, first and second order sensors.

Photoelectric effect - photo dielectric effect - photoluminescence effect - electroluminescence effect - chemiluminescence effect - Barkhausen effect - Hal effect - Ettinshausen effect - thermoelectric effect - peizoresistive effect – piezoelectric effect - pyroelectric effect - Magneto-mechanical effect (magnetostriction) - Magneto resistive effect.

Unit:2	Physical Sensors	12 hours

Mass sensor- Nanogram Mass Sensing by Quartz Crystal Microbalance - Displacement sensor- Electron Tunneling Displacement Nanosensors; Magnetomotive Displacement Nanosensor - Piezoresistive and Piezoelectric Displacement Nanosensors,- Force sensor - Femtonewton Force Sensors- Pressure sensor - Membrane-Based CNT Electromechanical Pressure Sensor – Accelerometer – Tunnel effect accelerometer- Silicon Nanowire Accelerometer – Flow sensor - CNT Flow Sensor for Ionic Solutions – Temperature sensor – CNT based Resistive Low-Temperature Nanosensor- Silicon Nanowire Temperature Nanosensors – Light sensor – CNT/Polymer Nanocomposite as Conductivity Response Infrared Nanosensor - Zinc Oxide Nanorods based Resistive UV Nanosensors.

Unit:3	Chemosensors	12 hours

Gas Sensing with Nanostructured Thin Film, Adsorption on Surfaces, Conductometric transducers Suitable for Gas Sensing, Gas Reaction on the Surface, Effect of Gas Sensitive Structures and Thin Films- Metallic Nanoparticle Based Gas Sensors - Metal Oxide Gas Sensors - Carbon Nanotube Gas Sensors - Porous Silicon-Based Gas Sensor - Organic Polymer Film–Based Gas Sensors - Nanosensor Arrays - Nanoelectronic Nose – Optochemical Nanosensors.- Nanosensors Based on Surface-Enhanced Raman Scattering (SERS) - Colloidal Surface plasmon resonance (SPR) Colorimetric Gold Nanoparticle Spectrophotometric Sensor.		
Unit:4	**Biosensors**	**12 hours**
Nanoparticle-Based Electrochemical Biosensors –DNA enabled biosensors - CNT-Based Electrochemical Biosensors - Functionalization of CNTs for Biosensor Fabrication Quantum Dot-Based Electrochemical Biosensors - Nanotube- and Nanowire-Based FET Nanobiosensors - Cantilever-Based Nanobiosensors - Optical Nanobiosensors.		
Unit:5	**IoT Based Sensors**	**12 hours**
Internet of things – Building blocks of IoT, Characteristics of IoT- Design of IoT - connectivity – mobile-satellite-Bluetooth -Wi-Fi – Wimax- IoT enabled technologies – IoT communication models -Internet of nano things - sensor network – Applications – Agriculture – Transport – Environment – Health care – wearable devices.		
Unit: 6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars– webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Nanotechnology-Enabled Sensors, Kourosh Kalantar-zadeh, Benjamin Fry, Springer, New York, (2010).
2	Nanosensors: Physical, Chemical and Biological, Vinod Kumar Khanna, CRC,(2012).
3	Internet of Things: A hands on approach, A. Bagha, V. Madisetti, Bagha and Madisetti Publishers,(2014).
Book (s) for Reference	
1	Teik-Cheng Lim, Nanosensors: Theory and Applications in Industry, Healthcare and Defense, CRC,(2011).
2	Kevin C. Honey church, Nanosensors for Chemical and Biological Applications: Sensing with Nanotubes, Nanowires and Nanoparticles, woodhead publishing (2014).
3	Biosensor, Rajmohan Joshi, Isha Books, New Delhi, (2006).
4	Chemical sensors and Biosensors, Brain R. Eggins, John-Wiley, New York, (2002).
5	Smart Biosensor Technology, Bassi.A.S and Knopf.G.K, CRC Press, New York,(2007).
6	Sensors: Principles and Applications, Peter Hauptmann and Tim Pownall, Prentice Hall, (2003).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://onlinecourses.nptel.ac.in/noc19_ee41/preview
2	https://nptel.ac.in/courses/108/106/108106165/
3	https://nptel.ac.in/courses/115/107/115107122/
4	https://nptel.ac.in/courses/106/105/106105166/

Course Designed By	**Dr R. T. Rajendrakumar**	e-mail	rtrkumar@buc.edu.in

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	S	M	S	M	M	M	L	S
CO2	M	S	M	S	S	M	L	S	M	L
CO3	M	L	L	S	M	S	M	M	L	M
CO4	M	L	L	L	M	S	L	S	S	L
CO5	M	L	M	L	L	M	L	M	M	S
S	Strong			**M**	Medium			**L**	Low	

Course code	33D	ADVANCES IN NANOBIOTECHNOLOGY	L	T	P	C
Core						
Pre-requisite		Understanding of Nanotechnology concepts and biology	Syllabus Version		2020 -2021	

Course Objectives:

1. Understand the principles of drug delivery systems and control of varied parameters for effective drug delivery
2. Gain knowledge on the mode of action of nanoparticle activity inside the cellular structure
3. Inculcate the concepts of advances in Nano therapeutics

Expected Course Outcomes:

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

1	Remember the elemental principles of drug delivery systems	K1
2	Understand the mode of action of nanoparticles and it's in vitro toxicity assays	K2
3	Recent developments and understanding the available therapy in cancer treatment	K2
4	Explore and study the possibility of applying and analyze varied nanoparticles based targeted drug delivery	K4
5	Understanding of most recent advances in Nanobiotechnology with novel techniques	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Principles of Drug Delivery Systems	12 hours

Modes of drug delivery, Absorption distribution metabolism excretion characteristics of drugs, Controlled drug delivery - site specific drugs, Barriers for drug targeting - passive and active targeting, Strategies for site specific drug delivery.

Unit:2	Toxicity Assays and their Principles	12 hours

Cell viability, LDH release, ROS production, Morphological observation, Membrane potential, Live/Dead assay, Comet Assay, Cell cycle analysis and Apoptosis detection by flow cytometer

Unit:3	Nanoparticles and Cancer Therapy	12 hours

Cancer and its types: Mechanisms of progression in Cancer: Cellular trafficking, Cancer invasion, Migration, Angiogensis and Metastasis. Chemotherapy, Immunotherapy, Photodynamic Therapy (PDT), Photothermal Therapy (PTT), Magnetic Hyperthermia (MHT), High Intensity Focused Ultrasound (HIFU).

Unit:4	Targeted Drug Delivery	12 hours

Classification of targeted drug delivery systems, Bioconjugation, Nanoparticles surface modification - PEGylation, Gold nanoparticles for drug delivery, Magnetic nanoparticles as drug carriers.

Unit:5	3D Bio -Printing (Three Dimensional Bio-Printing)	12 hours

Introduction - History, principle and its components, Classification of 3D bio-printing techniques - Extrusion-based bio-printing, Droplet-based bio-printing, Laser-based bio-printing, Design Requirements for 3D Bio-printing- Magnetic Resonance Imaging, Computed

Tomography, Computer-Aided Design Based Systems, 3D modelling softwares, Bio inks for 3D bio-printing - Applications of 3D Bio-printing and future trends.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Drug delivery: Fundamentals and applications Hillery A M.,&Park,K.(Eds.).CRC Press, (2016).
2	Handbook of Nanomaterials for Cancer Theranostics. Conde, J. (Ed.). (2018).
Book (s) for Reference	
1	Drug delivery: Principles & applications Wang, B., Hu, L, Siahaan, T.J, John Wiley& Sons, (2016).
2	3D Bio-printing -Fundamentals, Principles and Applications, Ibrahim T. Ozbolat, Academic Press, (2016).
3	3D Bio-printing in Regenerative Engineering, Principles and Applications, Ali Khademhosseini, Gulden Camci-Unal, 1st edition, CRC press, (2018).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://doi.org/10.1021/acs.chemrev.7b00258
2	https://doi.org/10.5772/intechopen.71923

Course Designed By	**Dr P. Premasudha**	e-mail	premasudha@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	L	L	M	S	M	S	S	S
CO2	S	S	M	M	S	S	S	S	S	S
CO3	S	S	M	S	S	S	S	S	S	S
CO4	M	S	M	M	S	S	S	S	S	S
CO5	S	S	S	S	S	S	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	3EA	ENVIRONMENTAL SUSTAINABILITY OF NANOMATERIALS	L	T	P	C
Core			4	0	0	4
Pre-requisite		General concepts of nanomaterials and their functional properties.	Syllabus Version		2020 - 2021	

Course Objectives:

The main objectives of this course are to:

1. Familiarize the students with basics of nanomaterials for environmental sustainability.
2. Enhancing the knowledge of the students in nanomaterials for environmental remediation.
3. Study on the development of green energy sources using nanomaterials.
4. Enhancing the knowledge on CO_2 capturing.

Expected Course Outcomes:

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

1	Describe beneficial effects of sustainable nanotechnology on climate-change, improvement in our life quality, and promotion of natural resources	K3
2	Describe principles of catalysis (including photocatalysis) and the various common applications in environmental treatment	K4
3	Describe nanomaterials (including carbon nanotubes and nanostructured films/membranes) in membrane based water treatments as well as new nanotechnology based water treatment methods	K4
4	Improve the functional properties of photocatalysts and photoelectrocatlysts.	K5
5	Learn advanced energy conversion sources such as water splitting and CO_2 reduction	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Environmental issues in Water and Remediation	12 hours

Emerging Contaminants in Water: Sources and Occurrence- Pharmaceutical Residues- Natural and Synthetic Estrogens - Drugs of Abuse- Surfactants (Alkylphenol Ethoxylates and Related Compounds)- Perfluorinated Compounds- Industrial Chemicals (Corrosion Inhibitors and Plasticizers) - Human versus Ecological Health Effects-Industrial Chemicals–Alkylphenols, perchlorate, perfluorochemicals, Phthalates, Polychlorinated Naphthalenes, Personal Care Products. Industrial contaminants – textile dyes – Methyl orange and methylene blue. Methods to remove contaminants - Activated Carbon Adsorption- Oxidation Processes- Ozonation– Chlorination – Chlorine Dioxide – Membrane separation – Ultrafiltration – Nanofiltration/reverse Osmosis.

Unit:2	Photocatalysis for Environmental Remediation	12 hours

Introduction –Definition – Types of photocatalysis –Photocatalytic reactions - Key Species in Photocatalytic Reactions - Reactive Oxygen Species - Trapped Electron and Hole - Superoxide Radical and Hydrogen Peroxide - Hydroxyl Radical (OH•) - Singlet Molecular Oxygen - Reaction Mechanisms for Bare TiO_2 - Reaction Mechanisms of Visible-Light-Responsive Photocatalysts - Photocatalytic Reaction Pathways – Effects of Molecular Structure, Catalyst, and Wavelength - Methods for Pathway Determinations - Prototypical Oxidative Reactivity in Photocatalytic Degradations - Alcohol Fragmentation and Oxidation

Unit:3	Understanding Photocatalysis and Photocatalyts	12 hours

Photocatalyic - Rate Kinetic models – Substrate-Mediated Recombination - Surface Speciation - Different Commercial Catalysts (TiO_2) - Surface Manipulation - Crystal Faces - Surface Traps

for Holes - Multisite Kinetic Model - Improving the Photocatalytic Efficacy - Thermodynamic Aspect of Photocatalysis - Design of Active Photocatalysts - A Conventional Kinetics in Photocatalysis: First-Order Kinetics - Langmuir–Hinshelwood Mechanism - Problems Related to Particle Size of Photocatalysts - Recombination of a Photoexcited Electron and a Positive Hole - Electron Traps as a Recombination Center - Dependence of Photocatalytic Activities on Physical and Structural Properties - Synergetic Effect–Doping Design of Photocatalytic Reactors - Rotating disk reactor system - continuous-flow reactor system.

Unit:4	**Water Splitting for Hydrogen Production**	**12 hours**

General – The water splitting reaction – Natural water splitting – Water oxidation catalysts – Semiconductors for water splitting – Dye sensitized photocatalysts – Electrochemical measurement as screening method for water oxidation – preparation of active electrodes – wet method – dry method – Assessment of electrocatalytic activity.

Unit:5	**Nanotechnology for Carbon Dioxide Capture**	**12 hours**

Introduction – CO_2 as a resource – Circulate CO_2 economy - CO_2 capture/Separation technologies – Direct air capture and nanomaterials – nanomaterials – MOF – Gas separation – CNTs – Nanoporous membranes – Nanocrystals – Nanoparticle ionic materials – CuO loaded porous carbon – selectively permeable membranes – cellulose based porous nanomaterials – Nanocomposites.

Unit:6	**Contemporary Issues**	**2 hours**

Expert lectures, online seminars – webinars

	Total Lecture hours	**62 hours**

Book (s) for Study

1	The Hand book of Environmental Chemistry, O. Hutzinger, D. Barceló, A. Kostianoy (Editors), Springer-Verlag Berlin Heidelberg, 2008.
2	Photocatalysis and Water Purification - From Fundamentals to Recent Applications, Pierre Pichat (Editor), Wiley-VCH Verlag GmbH &Co. K Ga A, Boschstr. 12, 69469 Weinheim, Germany 2013.
3	Testing Novel Water Oxidation Catalysts for Solar Fuels Production, Ed. By Carminna Ottone, Simelys Hernández, Marco Armandi, Barbara Bonelii, Springer, 2019.
4	Nanomaterials and Direct Air Capture of CO_2, Dirk Fransaer, Nanotechnology for Energy Sustainability, Ed. Marcel Van de Voorde, Wiley VCH, 2017.

Book (s) for Reference

1	Nanomaterials for Environmental Protection, Ed. By Boris I. Kharisov, Oxana V. Kharissova, H. V. Rasikha Dias, John Wiley, 2015.
2	Nanotechnologies for Environmental Remediation : Applications and Implications, edited by Giusy Lofrano, Giovanni Libralato, Jeanette Brown, Springer, 2016.
3	Hydrogen Production by Electrolysis, Edited by AgataGodula –Jopek, Wiley – VCH, 2015.
4	Environmental Applications of Nanomaterials: Synthesis, Sorbents and Sensors By Glen E. Fryxell, Guozhong Cao, Imperial Collge Press, 2007.

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

1	https://nptel.ac.in/content/storage2/courses/105108075/module9/Lecture40.pdf
2	https://nptel.ac.in/courses/118/107/118107015/
3	https://nptel.ac.in/courses/105/107/105107181/

4	https://onlinecourses.nptel.ac.in/noc20_ce31/preview
5	https://nptel.ac.in/courses/112/107/112107283/
6	https://nptel.ac.in/courses/112/107/112107283/

Course Designed By	**Dr N. Ponpandian**	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	L	M	S	S	S	S	S	S
CO2	S	M	L	M	S	S	S	S	S	S
CO3	S	L	M	S	S	S	S	S	S	S
CO4	S	L	M	S	S	M	S	S	S	S
CO5	M	M	L	S	S	M	S	S	S	S
S	Strong		**M**	Medium		**L**	Low			

Course code	3EB	SOCIETAL IMPACTS OF NANOTECHOLOGY	L	T	P	C
Elective			4	0	0	4
Pre-requisite		General concepts of nanomaterials and their functional properties.	Syllabus Version		2020 - 2021	

Course Objectives:

The main objectives of this course are to:

1. To impart the knowledge about the economic impact of nanotechnology.
2. Understand the various social impacts of nanotechnology trend and research.
3. To impart the knowledge about ethics and laws related to nanotechnology

Expected Course Outcomes:

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

1	Analyze the economic impact of nanotechnology	K3
2	Understand the ethics and laws related to nanotechnology	K4
3	Understand the societal impacts of nanotechnology	K4
4	Analyze the legal risks on nanotechnology.	K5
5	Understand the product scaling up in nanotechnology.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Protection and Regulation for Nanotechnology	12 hours

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

Unit:2	Liability Legal Aspects of Nanotechnology	12 hours

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

Unit:3	Economic Impacts and Commercialization of Nanotechnology and Social Scenarios	12 hours

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

Unit:4	Ethics, Law and Governance	12 hours

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

Unit:5	**Public Perceptions and Education**	**12 hours**
Public Perceptions-Societal Implications of Nanoscience: An Agenda for Public Interaction Research -Communicating Nanotechnological Risks- A Proposal to Advance Understanding of Nanotechnology's Social Impacts -Nanotechnology in the Media: A Preliminary Analysis-Public Engagement with Nanoscale Science and Engineering -Nanotechnology: Moving Beyond Risk-Communication Streams and Nanotechnology: The (Re)Interpretation of a New Technology-Nanotechnology: Societal Implications — Individual Perspectives-Historical Comparisons for Anticipating Public Reactions to Nanotechnology.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**62 hours**

Book (s) for Study	
1	Mihail. C, Roco and William Sims Bainbridge "Nanotechnology: Societal Implications II-Individual Perspectives", Springer, 2007.
2	Geoffrey Hunt and Michael. D, Mehta "Nanotechnology: Risk, Ethics and Law", Earthscan/James & James publication, 2006.
3	Jurgen Schulte "Nanotechnology: Global Strategies, Industry Trends and Applications", John Wiley & Sons Ltd, 2005.
4	Mark. R, Weisner and Jean-Yves Bottero "Environmental Nanotechnology applications and impact of nanomaterial", The McGraw-Hill Companies, 2007.
Book (s) for Reference	
1	Jurgen Schulte ―Nanotechnology: Global Strategies, Industry Trends and Applications‖, JohnWiley & Sons Ltd (2005).
2	Mark. R. Weisner and Jean-Yves Bottero ― Environmental Nanotechnology applications andimpact of nanomaterial‖, The McGraw-Hill Companies (2007).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/103/105/103105122/
2	https://nptel.ac.in/content/storage2/courses/105108075/module9/Lecture40.pdf
3	https://www.azonano.com/article.aspx?ArticleID=4992

Course Designed By	**Dr N. Ponpandian**	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	M	L	M	S	S	S	S	S	S
CO2	S	M	L	M	S	S	S	S	S	S
CO3	S	L	M	S	S	S	S	S	S	S
CO4	S	L	M	S	S	M	S	S	S	S
CO5	M	M	L	S	S	M	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	37V	SUMMER INTERNSHIP PROJECT	L	T	P	C
Core			0	0	2	2
Pre-requisite		Basic knowledge and understanding in physics, chemistry and biology in addition to nanoscience and technology	Syllabus Version		2020 -2021	

Course Objectives:

1. Widening the student's perspective by providing an exposure to real life organizational environment and its various functional activities.
2. This will enable the students to explore an industry/organization, build a relationship with a prospective employer, or simply hone their skills in a familiar field.
3. It also provides invaluable knowledge and networking experience to the students.
4. An additional benefit that organizations may derive is the unique opportunity to evaluate the student from a long-term perspective. Thus this internship can become a gateway for final placement / higher education of the student.
5. The student should ensure that the data and other information used in the study report is obtained with the permission of the institution concerned. The students should also behave ethically and honestly with the organization.

Expected Course Outcomes:

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

1	Practical experience in an organizational setting.	K4
2	Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.	K2
3	Opportunity to learn new skills and supplement knowledge.	K3
4	Opportunity to practice communication and teamwork skills.	
5	Opportunity to learn strategies like time management, multi-tasking etc in an Research/industrial setup	

K1– Remember; **K2**–Undestand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

The total marks for the Summer Internship Project will be 50 and it carries 2 credits. The marks will be awarded for the following aspects:

1	**Introduction:** Clear understanding of the topic/subject; understanding of the organisation/unit//field as well as review of similar studies
2	**Details about the study:** Objectives, formulation of the problem, scope, and rationale of the study.
3	**Methods/methodology adopted for the study:** Analytical, Survey, Field Work or any other method with appropriate justification and reasoning.
4	**Analysis and conclusions:** The logic of analysis, source of data, whether the conclusions are in line with the objectives, etc.
5	**Contribution and learning from the project:** Details of the contribution of the study,, the benefits to the organisation, the learning from the study for the student, etc.
6	**Acknowledgements:** References/Citations and Bibliography and help, if any,, received from other individuals/organisations.
7	**Presentation of the report, format of the report, flow of the report, style, language, *etc*.**

8	**Presentation of the report to the examiners:** Substance and treatment of the topic, style of presentation, performance in the question answer session, time management, language, etc.
9	Overall impression.
10	It also includes the report on the study tour during I and III Semesters.

Course Designed By	**Dr N. Ponpandian**	**e-mail**	**ponpandian@buc.edu.in**

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	S	S	L	S	S
CO2	S	S	L	L	S	S	M	M	M	S
CO3	S	S	M	M	S	S	M	L	S	S
CO4	S	S	L	M	S	S	L	M	M	S
CO5	S	S	L	L	S	S	M	M	M	S

S	Strong		**M**	Medium		**L**	Low

Course code	33P	PRACTICAL – III – APPLICATIONS OF NANOMATERIALS	L	T	P	C
Core			0	0	4	4
Pre-requisite		Basic knowledge and understanding in nanoscience, physics, chemistry and biology.	Syllabus Version		2020 -2021	

Course Objectives:

To impart training in operating different instruments used in the analysis of various, physical, chemical, and biological constituents and study the applications of nanomaterials.

Expected Course Outcomes:

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

1	Understand the design aspects of application specific Nanoscale Devices.	K4
2	Learn material's properties used for the fabrication of nanosensors.	K2
3	Understand the functionalization and applications of nanomaterials.	K3
4	Acquire the knowledge of electrochemical energy storage systems and biomedical applications	K5
5	Having an ability to use techniques, skills and modern tools necessary for practical applications	K6

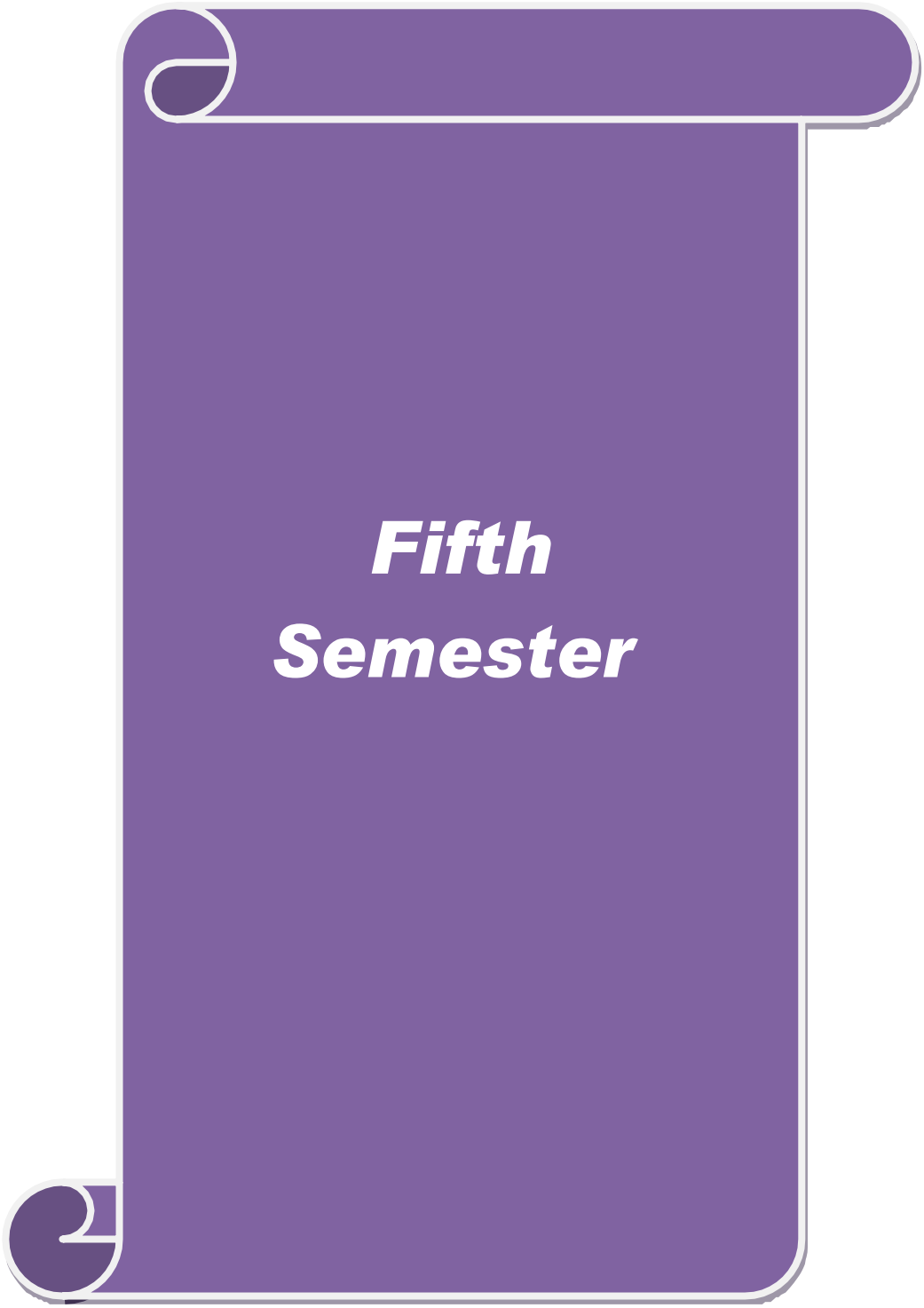
K1– Remember; **K2**–Understand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

Practical

1	Electrochemical properties of nanoparticles using cyclic-voltammetry
2	Electrochemical sensors for the detection of pollutants in water
3	Gold nanoparticle based SERS sensing characteristics of toxic compound
4	Evaluating gas sensing parameters for a given nanosensor
5	Determination of charge storage efficiency, energy density of a given nanomaterials based supercapacitor
6	Evaluation of photocatalytic degradation efficiency of a give nanomaterial against organic dye degradation.
7	Evaluation of the surface energy of a given nanomaterial using contact angle method
8	Analyzing the figures of merit of a field effect transistor based gas sensor
9	Determine the hydrogen evolution properties of a given electro catalyst
10	Verification of Lambert Beer's law and determination of concentration of unknown solution by UV-Vis spectrophotometer.
11	Fabrication of scaffolds
12	3-D printing of scaffolds
13	Cell isolation and seeding
14	Electro chemical corrosion experiment
15	Animal Cell Culture Techniques – Primary Cell Culture, Sub Culturing

Course Designed By	Dr N. Ponpandian	e-mail	ponpandian@bu

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	S	M	S	S	S	S	S	S
CO2	S	S	M	S	S	S	S	S	S	S
CO3	S	S	M	M	S	S	S	S	S	S
CO4	S	S	M	L	S	S	S	S	S	S
CO5	S	S	L	M	S	S	S	S	S	S
S	Strong		**M**	Medium			**L**	Low		


Fifth
Semester

Course code	43A	IPR and Biosafety	L	T	P	C
Core			2	0	0	2
Pre-requisite		Basic knowledge in intellectual property rights and laboratory safety.	Syllabus Version		2020 - 2021	

Course Objectives:

The main objectives of this course are to:

1. To understand the basic concepts of IPR and Biosafety concepts and its application in different levels.
2. To acquire knowledge on the process of patenting and its database searches, analysis and its report formation.
3. To know about IPR policy, Indian and International Laws on patent.
4. To acquire knowledge on Biosafety and its significance in different areas of science.

Expected Course Outcomes:

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

1	The students will get an overall understanding of basic history and classification of patenting.	K2
2	Learning the techniques to obtain database search in different portals and its analysis.	K4
3	To get equipped with the theoretical and practical understanding of patent writing, filling patent application and related structure and frames.	K5
4	To know the national and international laws of IPR.	K2
5	To learn about GMO, biosafety cabinets, principles and its guidelines.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Types of IP	6 hours

Patents – Trademarks - Copyright & Related Rights - Industrial Design - Traditional knowledge - Geographical indications - Protection of new GMOs; International framework for the protection of IP - Invention in context of "prior art" - Patent databases - Searching International Databases - Country-wise patent searches (USPTO, EPO, India etc.) - Analysis and report formation.

Unit:2	Types of Patents	6 hours

Indian patent act 1970 - Recent amendments - Patent application- forms and guidelines -Fee structure -Time frames - Filing of a patent application - Precautions before patenting- disclosure/non-disclosure - Patent application- Forms and guidelines -Fee structure -Time frames - Types of patent applications -Provisional and complete specifications - PCT and convention patent applications - International patenting – Requirement -Procedures and costs - Financial assistance for patenting-introduction to existing schemes.

Unit:3	IPR Policies	6 hours

IPR policy of Government of India - Indian &international patent laws - Indian patent act 1970; recent amendments - Financial assistance for patenting-existing schemes- Role of patents in biotechnology - The patentability of microorganisms - IPR and WTO regime - consumer protection and plant genetic resources-GATT and TRIPS - Patenting gene - Issues and case studies.

Unit:4	Biosafety	6 hours

Historical background - Introduction to biological safety cabinets - Primary containment for biohazards - Biosafety levels- Biosafety levels of specific microorganisms - Recommended biosafety levels for infectious agents and infected animals - Biosafety guidelines - Government of India.		
Unit:5	**Rules in Biosafety**	**6 hours**
Definition of GMOs & LMOs - Roles of institutional biosafety committee - RCGM, GEAC - GMO applications in food and agriculture - Environmental release of GMOs - Risk analysis - Risk assessment - Risk management and communication - Overview of national regulations and relevant international agreements including Cartagena protocol.		
Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars - webinars		
	Total Lecture hours	**32 hours**

Book (s) for Study	
1	Intellectual Property Law, P. Narayanan, 3rd Edition, Eastern Law House, 2018.
2	Intellectual Property Law, Meenu Paul, Reprint, Allahabad Law Agency, 2018.
3	Biotechnology, John E. Smith, 5thEdition, Cambridge University Press, 2012.
Book (s) for Reference	
1	Intellectual Property Law containing Acts and Rules, Universal Law Publication Company.
2	Intellectual Property Rights, Neeraj Pandey, Khusdeep Dharni, PHI Learning (P) Ltd., 2014.
3	Laboratory biosafety manual Third edition, World Health Organization, 2004.
4	Biological Safety: Principles and Practices, 5th Edition, **Volume 25, Number 1,** Dawn P. Wooley; Karen B. Byers, ASM Press, Washington, DC, USA, 2017.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/109/106/109106137/
2	https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-hs45/
3	https://nptel.ac.in/courses/109/106/109106148/
4	https://nptel.ac.in/courses/127/105/127105008/
5	https://onlinecourses.nptel.ac.in/noc20_hs18/preview

Course Designed By	**Dr N. Ponpandian**	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	L	S	M	M	S	S	S
CO2	S	M	M	M	M	L	L	S	S	S
CO3	S	S	M	L	S	S	M	S	S	M
CO4	S	S	M	L	M	M	S	S	S	S
CO5	S	S	M	M	S	S	S	S	S	S

S	Strong		**M**	Medium		**L**	Low

Course code	47V	PROJECT AND VIVA VOCE	L	T	P	C
Core			0	0	8	8
Pre-requisite		Basic knowledge and understanding in physics, chemistry and biology in addition to nanoscience and technology	Syllabus Version		2020 -2021	

Course Objectives:

1. To offer students an opportunity to demonstrate their competence in laboratory work.
2. To provide a vehicle for integrating the knowledge gained in various subjects of the degree course.
3. To allow the exercise of the undergraduates' personal qualities - *viz.* maturity, initiative and creative ability.
4. To apply communication skills, both oral and written, to communicate results, concepts and ideas.
5. To solve problems of a non-routine nature.

Expected Course Outcomes:

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

1	Ability to plan and implement an investigative or developmental project given general objectives and guidelines	K4
2	In-depth skill to use some laboratory / workshop equipment to process and characterize materials	K2
3	Ability to analyze data to produce useful information and to draw conclusions by systematic deduction	K3
4	Ability to work and study independently	
5	Apply the knowledge to design new research problems.	

K1– Remember; **K2**–Understand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

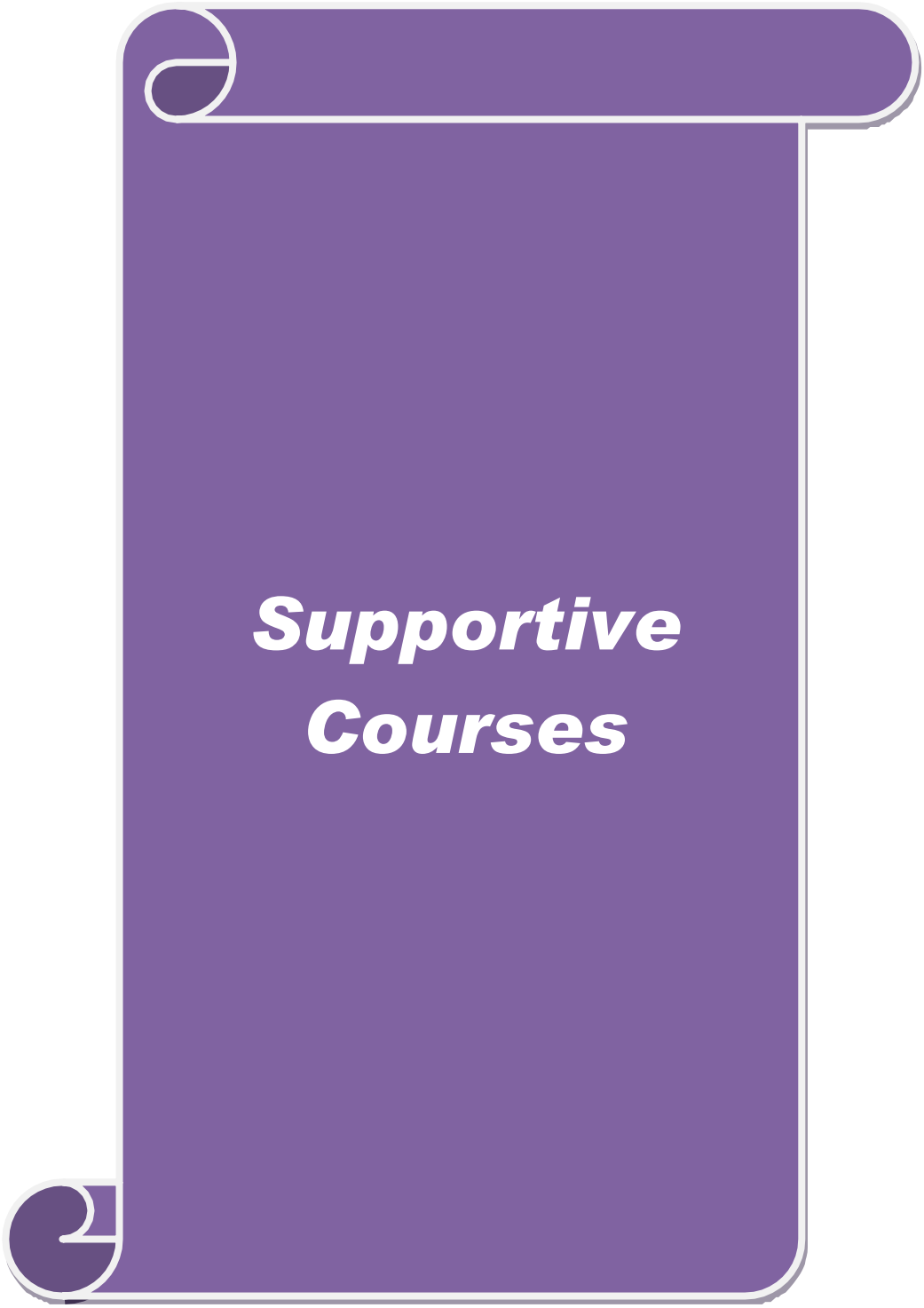
About the Project

1	The purpose of final year projects is to provide students an opportunity to apply the knowledge they have learnt, their intellectual abilities and practical skills to solving real, or close to real life engineering problems. These problems may take the form of an investigation or the development of devices or both.
2	Throughout the project, students are expected, with guidance from their supervisors, to do things and obtain information for themselves. Literature review, which provides the students a broader perspective of the work they are engaged in, is an essential part of the project. The projects are also organized with a view to develop their ability to communicate, both verbally and in writing. The verbal skill is developed through constant meetings and discussions with supervisors and assessed via an oral presentation towards the end of the projects. The writing skill is developed through report writing. These reports form the major part of the final assessment. Throughout the project exercise, students are trained, when necessary, how to use instruments, data analysis and interpretation effectively in order for a successful completion of the project. They also have to learn to how to optimize the outcomes under various constraints. Student progress is continuously monitored throughout the project duration.
3	Assessment Guideline of Project (75): a. Aim and Objectives of the Research (10) b. Methodology (15) c. Execution of the Research (20)

	d. Data Analysis (15) e. Writing (10) f. Conclusion (5)
4	Assessment Guideline of Power Point Presentation (25): i) Body language (5 marks) ii) Communication Skills (5 marks) iii) Content of the power point presentation (15 marks)

Course Designed By	**Dr N. Ponpandian**	e-mail	ponpandian@buc.edu.in

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	S	S	S	S	S
CO2	S	S	L	L	S	S	S	S	S	S
CO3	S	S	S	M	S	S	S	S	S	S
CO4	S	S	L	S	S	S	S	S	S	S
CO5	S	S	M	L	S	S	S	S	S	S
S	Strong			**M**	Medium			**L**	Low	


Supportive
Courses

Course code	1GS	INTRODUCTION TO NANOSCIENCE AND TECHNOLOGY	L	T	P	C
Supportive			2	0	0	2
Pre-requisite		Studied Physics/Chemistry/Biology/Any Allied subject during graduate Programme.	Syllabus Version		2020 -2021	

Course Objectives:

1. To understand the basic concepts of the atomic structure
2. To be able to get familiarized with the basic of chemical bonding
3. To lay foundation of nanoscience and technology
4. To enhance the knowledge about nano materials synthesis
5. To families with the basic characterizations of nanomaterials

Expected Course Outcomes:

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

1	Remember the basic structure of the atoms and molecules	K1
2	Understand the chemical bond formation	K2
3	Apply basic chemistry to prepare new nanomaterials	K3
4	Analyze the nanomaterials using different characterization techniques for conformation	K4

K1– Remember; **K2**–Understand; **K3**– Apply; **K4**– Analyze; **K5**– Evaluate; **K6**– Create

Unit:1	Basics of Atomic Structures	6 hours

Atoms, Molecules, Ions, Electrons & Periodic trends: Atomic models, Periodic table and electronic structures, Sizes of atoms & ions, Ionization Energy, Electron affinity and electron negativity, Trends in chemistry of groups.

Unit:2	Chemical Bonding	6 hours

Molecular structure and Bonding Theories: Atomic Bonding in solids, Types of bond: Metallic, Ionic, Covalent and Vender-Waals bond; Hybridization; Hydrogen bonding, Molecular orbital theory for simple molecules such as diatomic molecules etc.,

Unit:3	Basic Concepts of Nanoscience	6 hours

Nanoscience- Nanotechnology- Nanomaterials definitions,- Classification of carbon nanostructures- Allotropes, dimensions (one, two, three, and zero dimension), confinement- Surface to volume ratio-Energy at bulk and nano scale- Nature Nanophenomena- Size dependent variation in Physical- Chemical- Catalytic properties.

Unit:4	Synthesis of Nanomaterials	6 hours

Chemical precipitation and co-precipitation, Sol-gel synthesis, Microemulsions or reverse microemulsions, Solvothermal synthesis, Thermolysis routes, Metal nanocrystals by reduction, Microwave heating synthesis, Photochemical synthesis, Electrochemical synthesis, Sonochemical synthesis.

Unit:5	Characterization of Nanomaterials	6 hours

Optical Spectroscopy- UV-Vis Absorption Spectroscopy, Photoluminescence (PL) Spectroscopy, Fourier Transform Infrared Spectroscopy (FT-IR), Raman Spectroscopy.

Unit:6	**Contemporary Issues**	**2 hours**
Expert lectures, online seminars – webinars		
	Total Lecture hours	**32 hours**

Book (s) for Study	
1	Organic Chemistry, T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder, 12th Edition, John Wiley & Sons, New York, (2017).
2	Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley, Mark Geoghegan, John Wiley & Sons Ltd, (2005).
3	NANO: The Essentials- Understanding Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill Education (India) Private Limited, (2018).
4	Schodek, Nanomaterials, Nanotechnologies and Design M.F. Ashby, P.J. Ferreira, D.L, Elsevier, (2009).
5	Elementary Organic Spectroscopy, Y.R. Sharma, S. Chand Publishing, (2007).
Book (s) for Reference	
1	March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith, 8th Edition, Wiley, (2019).
2	Nanoparticle Technology Handbook, Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama, Elsevier Publications, (2007).
3	Encyclopedia of Materials Characterization, Series Editors: Butxetworch-Heinemann, C. Richard Brundle and Charles A. Evans. Jr, a division of Reed Publishing CUSA) Inc, (1992).
4	Introduction to Nanoscience and Nanotechnology, K K Chattopadhyay, Arghya Narayan Banerjee, PHI Learning, (2009).
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://swayam.gov.in/nd1_noc19_mm21/preview
2	https://swayam.gov.in/nd1_noc19_mm22/preview

Course Designed By	**DrP. Sakthivel**	e-mail	sakthivel.p@buc.edu.in

Course code	2GS	Applications of Nanotechnology	L	T	P	C
Supportive			2	0	0	2
Pre-requisite		Should have studied Physics/Chemistry/Biology/Fundamentals of Nanoscience/Any Allied Subject During Graduate Programme.	Syllabus Version		2020 -2021	

Course Objectives:

1. To learn nanotechnology applications.
2. Encourage the Students to carryout research in nanotechnology.

Expected Course Outcomes:

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

1	Understand the applications of nanomaterials in different fields	K1
2	Apply the natural dye materials for DSSCs	K3
3	Understand the different types of energy devices	K2
4	Fabricate nanomaterials for wastewater purification	K4
5	Design a Nanodevice for Biological Applications	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6**– Create

Unit:1	Nanomaterials for Solar Cells	6 hours

Principles of photovoltaic (PV) energy conversion, Types of photovoltaic cells, Physics of photovoltaic cells, Organic photovoltaic cells, Dye-sensitized solar cells (DSSCs), Quantum dot (QD)-sensitized solar cells (QD-SSC), Organic-inorganic hybrid bulk heterojunction (BHJ-SC) solar cells, Current status and future trends.

Unit:2	Nanomaterials for Energy Storage	6 hours

Introduction of energy storage devices, Issues and challenges of nanomaterials for electrochemical energy storage systems, Primary and secondary batteries (Lithium ion Batteries), Supercapacitor, Current status and future trends.

Unit:3	Nanomaterials for Agricultural Applications	6 hours

Nanotechnology in agriculture-Precision farming, Smart delivery system- Nanofertilizers: Nanourea and mixed fertilizers, Nanofertigation - Nanopesticides, Nanoseed.

Unit:4	Nanomaterials for Environmental Applications	6 hours

Environmental pollutants in the air, water, soil, hazardous and toxic wastes- Applications of nanotechnology in the remediation of Pollution in industrial and wastewater treatment- Drinking water and Air/Gas purifications.

Unit:5	Nanomaterials for Biological Applications	6 hours

Development of nanomedicines- Nanotechnology in the diagnostic application. Preformulation Studies: on various dosage forms such as tablets, capsules- suspension-creams- emulsion-injectables- ophthalmic and aerosols, etc. Gold nanorods: Multifunctional agents for cancer imaging and therapy- Fluorescent silica nanoparticles for tumor imaging

Unit:6	Contemporary Issues	1 hours

Expert lectures, online seminars– webinars		
	Total Lecture hours	**31 hours**
Book (s) for Study		
1	Handbook of Batteries, D. Linden Ed., 2nd Edition, McGraw-Hill, New York, (1995).	
2	Introduction to Nanotechnology, Charles P. Poole, Jr. Frank J. Owens, A John Wiley 81Sons, Inc., Publication, (2003).	
3	Nanotechnology: Applications in Energy, Shafiquzzaman Siddiquee, Gan Jet Hong Melvin, and Md. Mizanur Rahman, Drug and Food, Springer, Cham, (2019).	
4	C. Kumar, Nanomaterials for Medical Diagnosis and Therapy, Wiley –VCH, USA, (2007).	
5	Wiesner M R and Bottero JY, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill New York,(2007).	
Book (s) for Reference		
1	Polymer Matrix Composites and Technology, Ru-Min Wang Shui-Rong Zheng Yujun Zheng, 1stEdition, Woodhead Publishing, (2011).	
2	Nanoparticles Deliver RNAi Therapy, Materials Today, Martin C. Woodle, Patrick Y. Lu,(2005).	
3	Nanotechnology 101, John Mongillo, Greenwood Press, (2007).	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://nptel.ac.in/courses/113/106/113106093/	
2	https://nptel.ac.in/courses/102/107/102107058/	
3	https://nptel.ac.in/courses/102/104/102104069/	
4	https://nptel.ac.in/courses/112/107/112107283/	
Course Designed By	**Dr P. Sakthivel**	e-mail sakthivel.p@buc.edu.in

Value Added Courses

ANTIMICROBIAL TESTING	
Name of the Department	**Nanoscience and Technology**
Name of the Faculty Member i/c With Complete Address with Phone and e-mail	Dr P. Premasudha Assistant Professor Department of Nanoscience and Technology Bharathiar University Coimbatore 641 046 Mobile: 9843620645 Email : premasudha@buc.edu.in
Inter / Intra Department Course	Intra Department
Duration of the Course	30 hours
Eligibility	Microbiology / Biotechnology / Biochemistry /Botany / Zoology / Nanoscience
Number of Candidates to be Admitted	20
Registration Procedure	

Job Opportunities:

Pursue a career as a Microbiology Laboratory Technician for culture testing

Learn to suggest appropriate antibiotics

The objectives of the Course are:

The main objectives of this course are to:

1	To understand the principles of antimicrobial testing
2	To utilize specific monitoring techniques to evaluate the susceptibility of a microbe to different antibiotics
3	To distinguish the range of activity of an antibiotic
4	To recognize and define advantages and limitations of two different susceptibility testing procedures
5	Explain the significance of the minimal inhibitory concentration and the minimal bactericidal concentration relative to the effectiveness of an antimicrobial drug.

Course Content	Lecture / Practical / Project / Internship

Module 1	Introduction and Occurrence of Microorganisms (Bacteria and Fungi)	**3 - hours**
Module 2	Probiotics and Pathogenic Microorganisms	**3- hours**
Module 3	Discovery of Antibiotics Development	**3- hours**
Module 4	Development of Antibiotic Resistant Microbes.	**3- hours**
Module 5	Factors Governing in the Development of Antibiotic Resistant Microbes	**3- hours**
Module 6	Introduction of Antimicrobial Testing	**3- hours**
Module 7	Antimicrobial Testing Protocols - Bacteria	**3- hours**
Module 8	Antimicrobial Testing Protocols - Fungi	**3- hours**
Module 9	Nanomaterials in Antimicrobial Activity	**3- hours**
Module 10	Future Perspectives and Conclusion	**3- hours**

Book(s) for Study	
1	Geeta Sumbali and Mehrotra RS (2009). Principles of Microbiology. First edition,
2	Dubey RC and Maheswari DK (2012). A Text of Microbiology. Revised edition, S. Chand and Company Ltd., New Delhi
3	Ananthanarayan & Paniker's. (2013). Text Book of Microbiology, 9th Edition, Universities Press.
Book (s) for Reference	
1	Prescott L M, J P Harley and D A Klein (2005). Microbiology. Sixth edition, International edition, McGraw Hill.
2	Pelczar TR M J Chan ECS and Kreig N R (2006). Microbiology. Fifth edition, Tata McGraw-Hill INC. New York.
Related Online Contents	
1	Khan, Z. A., Siddiqui, M. F., & Park, S. (2019). Current and emerging methods of antibiotic susceptibility testing. Diagnostics, 9(2), 49. https://dx.doi.org/10.3390%2Fdiagnostics9020049
2	Reller, L. B., Weinstein, M., Jorgensen, J. H., & Ferraro, M. J. (2009). Antimicrobial susceptibility testing: a review of general principles and contemporary practices. Clinical infectious diseases, 49(11), 1749-1755. https://doi.org/10.1086/647952

ORGANIC SOLAR CELLS: MATERIALS DESIGN AND DEVICE CHARACTERIZATION		
Name of the Department	Nanoscience and Technology	
Name of the Faculty Member i/c With Complete Address with Phone and e-mail	Dr. P. Sakthivel Professor Department of Nanoscience and Technology Bharathiar University, 0422-428428, 9677560890	
Inter / Intra Department Course	Inter Department Course	
Duration of the Course	40 hours	
Eligibility	Chemistry, physics, Electronics, Nanoscience and Technology	
Number of Candidates to be Admitted	20	
Registration Procedure		
Job Opportunities: Solar cell Companies		
The objectives of the Course are:		
The main objectives of this course are to:		
1	Differentiate between small molecules and polymers	
2	Design conjugated small molecules and macromolecules	
3	Tune the HOMO, LUMO and band gap energy levels by theoretically	
4	Identification of suitable donor and acceptors for BHJ device fabrications	
5	Solar energy harvesting devices fabrication	
Course Content	Lecture	
Module 1	Introduction and overview of alternative energy sources and utilization	3 hours
Module 2	Principles of energy conversion: thermodynamic first and second laws, the Carnot cycle	3 hours
Module 3	Solar energy: Solar intensity and spectrum, global solar energy potential and current level of utilization	3 hours
Module 4	Review on Renewable and Nonrenewable energy resources	3 hours
Module 5	Discussion of different types of Organic Solar cells materials and state-of-the-art	4 hours
Module 6	Working principles of BHJ Devices with D-A Type DONOR and Fullerene ACCEPTORS	4 hours
Module 7	Designing DSSCs and conjugated Small/polymer solar cell materials and energy levels	5 hours
Module 8	Fullerene Acceptors Synthesis and Structural Studies	5 hours
Module 9	Overview of perovskite solar cell and state-of-the-art	5 hours
Module 10	Organic solar cells device fabrication techniques and Applications	5 hours
Book(s) for Study		
1	Wolfgang Tress, Organic Solar Cells, Theory, Experiment, and Device Simulation, Springer, Cham, 2014.	
2	S. Hegedus and A. Luque, “Handbook of Photovoltaics”, 2nd Ed. 2005.	
3	Martin A. Green “Solar Cells: Operating Principles, Technology and System Applications”(Prentice-Hall, Englewood Cliffs, N.J., 1982)ISBN: 0-85823-580-3.	
Book (s) for Reference		

1	Christoph Brabec, Ullrich Scherf, Vladimir Dyakonov, Organic Photovoltaics, Wiley-VCH, 2014
2	Modest Voronov, Organic Solar Cells: Advances in Research and Applications, NOVA Science Publisher, 2017.
Related Online Contents	
1	Prof. Soumitra Satpathi, Dept of Physics, IIT Roorkee, Solar Photovoltaics Fundamentals, Technology And Applications, https://nptel.ac.in/courses/115/107/115107116/
2	G. Chidichimo and L. Filippelli, Organic Solar Cells: Problems and Perspectives, Review Article | Open Access, 2010 |International Journal of Photoenergy, Article ID 123534 | 11 pages

PRACTICAL METHODS IN NANOTOXICOLOGY AND MOLECULAR GENETICS	
Name of the Department	**Nanoscience and Technology**
Name of the Faculty Member i/c With Complete Address with Phone and e-mail	**Dr. P. P. Vijaya** **Professor** **Department of Nanoscience and Technology** **Bharathiar University** **Coimbatore – 641 046** **Phone: +91 9840868328** **E-mail: vijayaparthasarathy@buc.edu.in**
Inter / Intra Department Course	**Inter and Intra Department Course**
Duration of the Course	**40 hours**
Eligibility	**B.Sc.,**
Number of Candidates to be Admitted	**25 – 50**
Registration Procedure	**Online**
Job Opportunities: CSIR-Central Leather Research Institute (CLRI) and CSIR- Central Drug Research Institute (CDRI) Laboratories.	
The objectives of the Course are:	
The main objectives of this course are to:	
1	To recapitulate the previous knowledge of Molecular Biology and biochemistry to design experiments.
2	Understand the DNA isolation and amplification techniques
3	To use the techniques and skills necessary for isolation of DNA and their further analysis.
4	Gain basic knowledge about recombinant DNA Technology
5	Distinguish the basic techniques in genetic engineering
Course Content	Lecture / ✓Practical / Project / Internship

Module 1	DNA Isolation - Isolation of genomic DNA from bacteria and plant cell.	**3 hours**
Module 2	Isolation of plasmid DNA from different type of bacteria by adopting different methods.	**3 hours**
Module 3	Purification and calculation of molecular weight of plasmid DNA. , plasmid curing (acridine orange, heat shock).	**3 hours**
Module 4	DNA and Protein Analysis: DNA: Southern and Northern Hybridization.	**3 hours**
Module 5	DNA Sequence Analysis (e.g Sangers Method), Automated Sequencing, RFLP and RAPD.	**3 hours**
Module 6	Protein: Western Blotting, ELISA and its variations	**3 hours**
Module 7	Human chromosomal aberrations- Plant (Allium cepa and Human lymphocyte cells); normal and abnormal karyotypes.	**3 hours**
Module 8	Preparation of E coli competent cells and their transformation using plasmid offering antibiotic resistance to the host cells	**3 hours**
Module 9	Restriction mapping of genomic/plasmid DNA (E.coli)	**3 hours**
Module 10	Competent cell preparation. Preparation of competent cells in E.coli and yeast.	**3 hours**

Book(s) for Study		
1	Molecular Biology of the Cell: Alberts et al., 6th Edition, Garland Publications,2015.	
2	Ansubel FM, Brent R, Kingston RE, Moore DD, "Current Protocols In Molecular Biology", 4th Edition, Greene Publishing Associates, NY, 2008	
3	Strachan T and Read A P, Human molecular genetics, 3rd Edition Wiley Bios, 2006.	
Book(s) for reference		
1	Old RW, Primrose SB, "Principles of Gene Manipulation, An Introduction To Genetic Engineering", 3rd Edition, Blackwell Science Publications, 2009.	
2	Jane K. Setlow, Genetic Engineering: Principles and Methods, Volume 27, Springer Science & Business Media, 2006	
Related Online Contents		
1	Essentials of Molecular Biology, Fourth Edition (2012) by V. Malathi., Pearson Education India.	
2	Microbial Genetics (2012) by **K. Chaudhuri, The Energy and Resources Institute, TERI.**	
3	Genetics – A Molecular Approach, 6th Edition (2013) by Bahman Yazdi Samadi , Mostafa Valizadeh, University of Tehran Press.	

Certificate Courses

1	**Name of the Course**	Solar Panel Installation Technician
2	**Name of the Department**	Nanoscience and technology
3	**Name of the Faculty Member**	Dr. C. Viswanathan Associate Professor Department of Nanoscience and Technology Bharathiar University
4	**Inter/Intra Department**	**Inter Department**
5	**Objectives of the Course**	The prime objective of the course is to produce highly skilled and technically qualified professional solar panel installers and also to guide them in career opportunities in solar power industry.
6	**Topics to be Covered**	i. Understand the basics of electricity and solar energy ii. Understand the site and equipment related requirements for solar PV installation iii. Design a solar PV system as per customer's requirements as well as appropriate codes and standards iv. Install a solar PV system based on the relevant designs v. Maintain a solar PV system and identify and troubleshoot problems vi. Ensure safety while installation and operation vii. Undertake project management for installation of a solar PV system
7	**Duration of the Course**	1 year
8	**Eligibility**	B.Sc, in Physics or Electronics
9	**Registration**	
10	**Description of the Course**	➢ Developing the knowledge basis of the trainee by covering various aspects of solar PV feasibility studies, basics of design, installation, operation and maintenance of solar panels ➢ Providing updated teaching materials ➢ Covering the technical and other capacity requirements for the solar industry ➢ Providing hands-on training in fabrication, design and installation of solar panels ➢ Exploring the local and global sectors from the experts
11	**Job Opportunities**	Solar panel Installation Technician at various electronic sector
12	**Number of Candidates**	15 No's per year
13	**Course Fee**	

ORGANIC SOLAR CELLS DEVICE FABRICATION		
Name of the Department	Nanoscience and Technology	
Name of the Faculty Member i/c With Complete Address with Phone and e-mail	Dr P. Sakthivel	
Inter / Intra Department Course	Inter Department	
Duration of the Course	3- 6 month/ 45 hours	
Eligibility	M.Sc. First/Second years: Physics, Chemistry, Electronics, Nanoscience	
Number of Candidates to be Admitted	20	
Mode of the Course	Both Regular and Online	
Collaboration if any with Companies (if Yes, Full Address of the Company Address , Name of the Contact Person, Phone, e-mail etc.)		
Registration Procedure	As per University Norms	
Job Opportunities: Solar Companies		
The objectives of the Course are:		
The main objectives of this course are to:		
1	Role of conjugated organic small molecules and macromolecules	
2	Study of conduction, Active and transporting layers in OSC Device	
3	The power conversion efficiency of OSC Device and JSC, FF, and FF	
4	Choice of solvents, additives, and acceptor	
5	Device characterizations	
Course Content	Lecture / Practical / Project / Internship	
Module 1	Primer of renewable energy: basics and production of energy with different resources	2 hours
Module 2	Fundamentals of Organic solar cells: Overview of organic molecules, conjugated small and polymers	4 hours
Module 3	Detailed study of Weak DONOR Alternate double bond systems and stability	4 hours
Module 4	Primary requirements for choosing ACCEPTOR and study of LUMO energy levels	5 hours
Module 5	Characteristic behaviors of Electrodes, transporting layers, and active layers	5 hours
Module 6	Study of mono layer, bilayer Organic Solar cells device fabrications	5 hours
Module 7	Bulk heterojunction solar cell device fabrications and their review on power conversion efficiency	5 hours
Module 8	Tandem organic solar cells device fabrication and their merits and demerits	5 hours
Module 9	Inverted organic solar cells device fabrication and stability study	5 hours
Module 10	Characterizations and OSCs Applications	5 hours
Book (s) for Study		
1	Christoph Brabec, Vladimir Dyakonow, and Ullrich Scherf, Organic Photovoltaics:	

	Materials, device physics, and manufacturing technology, Wiley VCH, 2009
2	Brutting W, Physics of Organic Semiconductors, Wiley VCH, 2005
Book (s) for Reference	
1	Hadziioannou G, Malliarass G. G, Semiconducting Polymers: Chemistry, Physics, and Engineering, Wiley VCH, 2007
2	Klauk H, Organic Electronics: Materials, Manufacturing, and Applications, Wiley VCH, 2006
Related Online Contents	
1	Prof. Soumitra Satpathi, Dept of Physics, IIT Roorkee, Solar Photovoltaics Fundamentals, Technology And Applications, https://nptel.ac.in/courses/115/107/115107116/
2	G. Chidichimo and L. Filippelli, Organic Solar Cells: Problems and Perspectives, Review Article | Open Access, 2010 |International Journal of Photoenergy, Article ID 123534 | 11 pages

NANOTOXICOLOGY – RISK ASSESSMENT AND MANAGEMENT	
Name of the Department	**Nanoscience and Technology**
Name of the Faculty Member i/c With Complete Address with Phone and e-mail	**Dr P. P. Vijaya** **Professor** **Department of Nanoscience and Technology** **Bharathiar University** **Coimbatore – 641 046** **Phone: +91 9840868328** **E-mail: vijayaparthasarathy@buc.edu.in**
Inter / Intra Department Course	**Intra Department Course**
Duration of the Course	**6 months**
Eligibility	**I OR II M.Sc.,**
Number of Candidates to be Admitted	**25 – 50**
Mode of the Course	**✓Regular / Online / Both Regular and Online**
Collaboration if any with Companies (if Yes, Full Address of the Company Address , Name of the Contact Person, Phone, e-mail etc.)	**Nil**
Registration Procedure	**Online**

Job Opportunities:

1. Marie Curie Early Stage Researcher –Ph.D., Studentship
2. Toxicity testing Laboratories in CSIR-Central Leather Research Institute (CLRI), CSIR-Central Drug Research Institute (CDRI) and Universities.
3. Job Opportunities in Pharmaceutical companies.

The objectives of the Course are:

The main objectives of this course are to:

1	To learn the basic importance and regulations of Nanotoxicology in nanotechnology fields.
2	To understand toxicity produced by nanostructures and methods to reduce their toxicity.
3	To provide knowledge on social impact of nanoindustry.
4	To design and conduct experiments, as well as to analyze the results.
5	To understand the socio-ethical responsibility

Course Content	✓Lecture / ✓Practical / Project / Internship

Module 1	Introduction – Definition of terms-Toxicity-Hazards and hazard types and assessment of risk.	**6 hours**
Module 2	Concept of Nanotoxicology - Laboratory rodent studies - Ecotoxicologic studies - Methodology for Nanotoxicology - in vitro and in vivo toxicity testing	**6 hours**
Module 3	Mechanism of nanosize particle toxicity - Reactive oxygen species meditated NSP toxicity - Interactions between Nanoparticles and Living Organisms: Mechanisms and Health Effects	**6 hours**
Module 4	Interactions of Nanoparticles with Cells and their Cellular	**6 hours**

	Nanotoxicology - Cytotoxicity of Ultrafine Particles - Cytotoxicity and Potential Mechanism of Nanomaterials- Immunotoxicity	
Module 5	Nanopollution – Nanomaterials in Environment - Toxicology of Airborne - Manufactured nanomaterials in the environment- Physicochemical characteristics of nanomaterials.	**6 hours**
Module 6	Biological Activities of Nanoparticles - nanoparticles interaction with biological membrane-Entry routes into the human body- Disposition of NSPs in the respiratory	**6 hours**
Module 7	Portals of entry and target tissue – Risk assessment – Ethical – Legal and Social Implications	**6 hours**
Module 8	Nanoparticle Toxicology and Ecotoxicology, The Role of Oxidative Stress – Development of Test Protocols for Nanomaterials – Regulation of Engineered Nanomaterials.	**6 hours**
Module 9	Nanotechnological Risks – Understanding of Nanotechnology's Social Impacts -Nanotechnology in the Media. Educating Undergraduate Nanoengineers, Education Opportunities – Human Resources for Nanotechnology	**6 hours**
Module 10	Ethical Issues in Nanoscience and Nanotechnology – Ethics & Law in a New Frontier- An Exploration of Patent Matters Associated with Nanotechnology	**6 hours**

Book(s) for Study

1	N. Duran, S.S. Guterres, O.L. Alves, Nanotoxicology: Materials, Methodologies, and Assessments, Springer, Newyork, 2014.
2	T. Otsuki, Y. Yoshioka, A. Holian, Biological Effects of Fibrous and Particulate Substances, Springer, Japan, 2016.
3	A.M. Gatti, S. Montanari, Case Studies in Nanotoxicology and Particle Toxicology, Academic Press, UK, 2015.

Book(s) for reference

1	Nancy A. Monteiro-Riviere, C. Lang Tran, Nanotoxicology: Progress towards Nanomedicine, Second edition, CRC Press, Taylor and Franscis, Boca Raton, 2014.
2	G. Ramachandran, Assessing Nanoparticle Risks to Human Health, William Andrew, Elsevier, USA, 2011.
3	J. Njuguna, K. Pielichowski, H. Zhu, Health and Environmental Safety of Nanomaterials: Polymer Nancomposites and other material containing nanoparticles, Woodhead Publishing, Elsevier, UK, 2014.

Related Online Contents

1	Encyclopedia of Toxicology (Third Edition), 2014.
2	Current Nanotoxicity and Prevention. Volume 1, 2 Issues, 2020 ISSN: 2665-9816.
3	Toxicology of Nanomaterials Editor(s): Yuliang Zhao, Zhiyong Zhang, Weiyue Feng, 2016.

Course code	----	REGENERATIVE MEDICINE	L	T	P	C
Core			4	0	0	4
Pre-requisite		This course is unique and innovative provides exposure to the students in the recent advances in medical science. The students are expected to have strong knowledge in material science and knowledge in biological systems.	Syllabus Version		2020 -2021	

Course Objectives:

1. The course aims to provide an in-depth knowledge of the field of regenerative medicine, from basic biology of stem cells to therapeutic applications.
2. Further, the course aimed to provide the translational knowledge of medicine and techniques to the participants.

Expected Course Outcomes:

After the completion of the course, the student will have the following capabilities:

1	Describe regenerative medicine and their specific characteristics.	KX
2	Describe methods of applications to replace damaged or destroyed cells including tissue engineering.	KX
3	Account for regenerative medicine applications to human diseases.	KX
4	Account for and evaluate current theories, methods and techniques within the research field, their practical execution and application.	KX
5	Compile, critically analyze and evaluate research results and present these both orally and in writing.	KX

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Basics of Regenerative Medicine	12 hours

Regenerative Medicine: Introduction- Bioreactors-Key Features-Controlled culture-Physical condition of developing tissues-Bioreactor based products.

Unit:2	Nanomaterials for Regenerative medicine	12 hours

Nanomaterials and Nanocomposites for Regenerative medicine: Perspective introduction-Types of nanocomposite 3D scaffolds-Drug free organ replacement-Carbon based composite regenerative medicine.

Unit:3	Surface Modification for Cell Interaction	12 hours

Chemical and Physical modified biomaterials for cell adhesion: General introduction-Methods to generate the nanostructured surface-Self assembled monolayer based poly (organosiloxanes)-**Injective hydrogels:** Introduction-Methods of preparation-Chemical and Physical reticulation process-Properties-Major issues on injectable process.

Unit:4	Cellular Therapeutics	12 hours

Introduction to stem cells-Molecular and cellular bases of tissue and organ development-Therapeutic uses of stem cells-Molecular bases of dieases-Bio-Artificial organs.

Unit:5	Tissue Therapy	12 hours

Engineering of small and large diameter blood vessels-Cardiac tissue-Intracorporeal kidney support-Genito urinary system-Reproductive system-Tissue therapy implications of regenerative medicine-Current issues and challenges.

Unit:6	Contemporary Issues	2 hours

Current challenges and regulatory issues will be addressed by the experts in the respective domain.

	Total Lecture hours		**62 hours**
Text Books			
1	Principles of Regenerative Medicine, Anthony Atala, Robert Lanza, Tony Mikos, Robert Nerem, 3rd edition, **2018**, **ISBN: 9780128098806.**		
2	Nanomaterials for regenerative medicine, Tekinay, Ayse, Springer, 2019, ISBN: 978-3-030-31202-2.		
Reference Books			
1	Foundation of Regenerative Medicine, Anthony Atala, 1rd edition, **2009, ISBN: 9780123785626.**		
2	Advances in Regenerative Medicine: Role of Nanotechnology, and Engineering Principles, Venkatram Prasad Shastri, George Altankov, Andreas Lendlein, ISBN 978-90-481-8788-1, 2007.		
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]			
1	https://www.ncbi.nlm.nih.gov		
2	https://onlinelibrary.wiley.com		
Course Designed By	**Dr A. M. Ballamuragan**	e-mail	balamurugan@buc.edu.in

Annexure

BHARATHIAR UNIVERSITY:: COIMBATORE 641046
DEPARTMENT OF NANOSCIENCE AND TECHNOLOGY
M.Sc., NANOSCIENCE AND TECHNOLOGY
(For the candidates admitted from the academic year 2022-23 onwards)
Overview, Curriculum and Syllabus

Duration: 2 Years

Level: Post-Graduation

Type: PG. Degree

Eligibility: Any undergraduate Science Degree recognized by UGC

VISION: To achieve excellence in the field of Nanoscience and Technology through academic and research programs and to participate in the interdisciplinary programs offered in the University.

MISSION: As a Department, We are committed to,

- Provide knowledge and skill in Nanoscience and Technology through post-graduate and doctoral programs.
- Undertake research in emerging areas of physical, chemical and biological sciences with Nanoscience and Technology and transform the findings for the benefit of the society.
- Solve the environmental issues through the post graduate and research programs.
- Provide required knowledge in physical, chemical and biological sciences to understand Nanoscience and Technology for research.

Career Opportunities: M.Sc. Nanoscience and Technology graduates have plethora job opportunities in the following fields;

- Research Scientist and formulation scientist
- Nanomaterial Product developer
- Government agencies for regulatory monitoring
- Patent examiner
- Entrepreneurship
- Consultancy organizations in pharmaceuticals, Energy, Material Science, Medical, Agriculture, Environment Protection.
- Job in Scientific Research Organizations.
- Enroll for higher degree through research in India or abroad
- Healthcare industry
- Teachers Recruitment Board (TRB) Tamil Nadu for Arts and Science Colleges.