NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

(Deemed to be University Under Section 3 of the UGC Act, 1956)
Kumaracoil, Thuckalay

DEPARTMENT OF NANOTECHNOLOGY

M.Tech. NANOTECHNOLOGY

CURRICULUM AND SYLLABI

REGULATION 2023

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, KUMARACOIL

Regulation 2023

Curriculum and Syllabi

DEPARTMENT OF NANO TECHNOLOGY

M. Tech. NANO TECHNOLOGY

Vision of the University

To be recognized by the Government and society at large as an institution able to deliver excellence with relevance in the field of higher education and research focusing on the needs of the nation in tune with the technological revolution to cope with the knowledge explosion and global competence.

Mission of the University

To develop the institution as a Centre of Excellence, keeping pace with the advances in the field, so as to provide quality higher education to the students and instill in them high standards of discipline and ethics so that they become enlightened individuals in the service of humanity and to carry out focused research in the frontier areas of science and technology.

Faculty of Information and Nano Technology

Department of Nano Technology

Vision of the Department

To develop professionals with strong technical and research backgrounds by contributing to the society through applications of nanotechnology for the betterment of the nation.

Mission of the Department

The Nanotechnology department is committed to continually improve the educational environment by providing quality education in both theoretical and applied foundations of nanotechnology to create highly skilled engineers, capable of doing research to produce quality publications and encouraging technology transfer.

Description of the programme

Programme Educational Objectives - PEO	
PEO-01	**Engineering knowledge:** Acquire basic fundamental engineering knowledge in electronics, physics, mechanical, graphics, mathematics, biological sciences and material sciences.
PEO-02	**Logical skills:** Problem solving ability to link various disciplines and explore the interdisciplinary aspects of nanomaterials and their applications.
PEO-03	**Material synthesis and characterization:** Use critical knowledge generated for synthesizing materials and characterize it with available advanced tools.
PEO-04	**Design development:** To design and develop novel nanomaterials and substrates suitable for advanced applications through research projects.
PEO-05	**Knowledge dissemination:** To generate quality publication, planning of pilot studies relevant to modern industry based startups and incubation centres.
PEO-06	**Societal impact:** To identify the challenges in the society and to find solution with modern materials and application in terms of health, environment, energy, etc.

Graduate	
GA-1	**Innovative Engineering Solutions** Develop creative and innovative solutions to complex engineering problems, incorporating the latest technologies and approaches to address current and future challenges.
GA-2	**Global Perspective in Engineering** Understand and apply engineering solutions in a global context, recognizing the diversity of global issues, standards, and the impact of engineering decisions on different cultures and communities.
GA-3	**Sustainable Development and Green Engineering** Design and implement engineering solutions that prioritize sustainability, resource efficiency, and environmental protection, contributing to a sustainable future.
GA-4	**Social Responsibility and Community Engagement** Demonstrate a commitment to social responsibility by engaging with and contributing to local communities, understanding societal needs, and addressing
GA-5	**Adaptability and Lifelong Learning** Exhibit a proactive approach to continuous learning and adaptability, keeping pace with technological advancements and industry changes, and engaging in professional development activities.

GA-6	**Entrepreneurship and Innovation** Foster an entrepreneurial mindset, identifying opportunities for innovation and creating value through new technologies, products, and processes that meet market needs.
GA-7	**Interdisciplinary Collaboration** Work effectively in interdisciplinary teams, integrating knowledge from various fields to develop comprehensive solutions to complex engineering problems.
GA-8	**Ethical Leadership and Integrity** Lead with integrity and ethical principles, ensuring transparency, fairness, and respect in all professional and personal interactions.
GA-9	**Digital and Data Literacy** Utilize advanced digital tools and data analytics techniques to solve engineering problems, optimize processes, and make informed decisions based on data-driven
GA-10	**Safety, Health, and Risk Management** Prioritize safety, health, and risk management in engineering practices, ensuring the well-being of individuals and communities while minimizing potential risks and
GA-11	**Effective Communication and Negotiation Skills** Communicate ideas, solutions, and technical information effectively to a variety of audiences, and engage in negotiation to resolve conflicts and reach consensus.
GA-12	**Impact Assessment and Policy Making** Assess the impact of engineering projects on society and the environment, and contribute to policy-making processes that promote sustainable and responsible

Programme Outcome – PO	
PO-A	By the end of the program, the student will have 1) In-depth knowledge in optics, electronics, physical, mechanical and biological techniques.
PO-B	2) the student will have a cross linking or inter disciplinary knowledge and problem solving skills for different research challenges.
PO-C	3) the student will be capable of chemical and green synthesis routes, can handle software and modern instrumentation for characterization.
P0-D	4) can design practical platforms with novel nanomaterials and chip based sensors, implants and MEMS.
PO-E	5) can write projects, publications, patents, proposals and design novel tools and materials for research sectors.
PO-F	6) can work in any sector related to energy, space, environment and health to develop novel technologies towards existing challenges

Mapping of Graduate Attributes and Programme Educational Objectives(PEO)

GAs / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10	GA-11	GA-12
PEO-01	**HA**	**HA**	**HA**									
PEO-02					**HA**						**HA**	
PEO-03			**HA**			**HA**						
PE0-04	**HA**		**HA**			**HA**			**HA**			
PEO-05				**HA**			**HA**	**HA**		**HA**		**HA**

H- Highly Associated A- Associated Not – Not Associated

Mapping of Graduate Attributes and Programme Outcomes (PO)

Gas / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10	GA-11	GA-12
PO-A	**HA**											
PO-B		**HA**										
PO-C			**HA**									
P0-D				**HA**								
PO-E					**HA**	**HA**	**HA**					**HA**
PO-F								**HA**	**HA**	**HA**	**HA**	

H- Highly Associated A- Associated Not – Not Associated

Mapping of Programme Educational Objective (PEOs) and Programme Outcomes (POs)

PEO / PO	PEO-01	PEO-02	PEO-03	PEO-04	PEO-05	PEO-06
PO-A	H					
PO-B		H				
PO-C			H			
P0-D				H		
PO-E					H	
PO-F						H

H- Highly Associated A- Associated Not – Not Associated

Duration of the programme: 2 Years/ 4 Semesters

Total credit : 70

DEPARTMENT OF NANO TECHNOLOGY

M. TECH. NANO TECHNOLOGY

REGULATION 2023

SEMESTER I

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA4501	Advanced mathematics	3	1	0	4
2.	NT4501	Quantum Mechanics in Nanostructures	3	0	0	3
3.	NT4502	Fundamentals of Nanoscience and Technology	3	0	0	3
4.	NT4503	Synthesis of Nanomaterials	3	0	0	3
5.	NT45XX	Department Elective I	3	0	0	3
6.	NT45XX	Department Elective II	3	0	0	3
PRACTICAL						
7.	NT4571	Synthesis and Preparation of Nanomaterials Laboratory	0	1	2	2
TOTAL			**18**	**2**	**2**	**21**

SEMESTER I

MA4501	**ADVANCED MATHEMATICS**	**L T P C**
	(Common to CS, AE, C&I, NT)	**3 1 0 4**

AIM:

To gain a well found knowledge of optimizing a function and variation problems which provide necessary mathematical support and confidence to tackle real life problems.

OBJECTIVE:

The course objective is, the students will be able to apply various methods in Linear Algebra to solve the system of linear equations, use two-dimensional random variables, and correlations in solving application problems apply the ideas of Random Processes and understand the basic characteristic features of a queueing system and acquire skills in analyzing queueing models.

Subject Code: ma4501	**Subject Name: ADVANCED MATHEMATICS**	
Course Outcome – Cos		**Cognitive Skill**
CO-01	Compute various methods in Linear Algebra to solve the system of linear equations.Using generalized eigenvectors, find the inverse of a singular matrix using the Pseudo inverse method.	R, U, A, E, An
CO-02	Formulate real-life problems and solve them using Linear Programming. Minimize the cost of distributing a product from many sources using TP. Assign a job to some workers so that the jobs are completed at the least cost or time.	R, U, A, E, An
CO-03	The random variable needs the analysis of random phenomena. Apply the concept of the moment, moment generating function. Extended one-dimensional random variables to two-dimensional random variables and analyze. Understand the concept of Correlation	R, U, A, E, An
CO-04	Know the concepts which describe the random wave transforms in a probabilistic sense.Trace the nature of random signals.Analyze the random signals in the frequency domain	R, U, A, E, An
CO-05	To understand the basic characteristic features of a queuing system and acquire skills in analyzing queuing models.	R, U, A, E, An

UNIT I LINEAR ALGEBRA (9)

Vector spaces – Norms – Inner products – Eigenvalues using QR transformations — Generalized eigenvectors – Jordan Canonical forms – Singular value decomposition and applications – Pseudo inverse

UNIT II LINEAR PROGRAMMING (9)

Formulation – Graphical solution – Simplex method: Big M Method– Transportation problems –

Assignment models

UNIT III PROBABILITY AND RANDOM VARIABLES (9)

Probability Concepts – Axioms of probability – Conditional probability – Random variables – Probability functions – Two-dimensional random variables – Joint distributions – Marginal and conditional distributions – Correlation.

UNIT IV RANDOM PROCESSES (9)

Classification – Stationary random processes – Ergodic process - The autocorrelation – Cross Correlations – Properties - Power spectral density, Cross Power spectral density.

UNIT V QUEUING THEORY (9)

Birth and Death process - Markovian queuing models – Little‟s formulae - M/M/1, M/M/C finite and infinite capacity (steady state solutions only)

L: 45 + T: 15, TOTAL: 60 PERIODS

REFERENCES:

1. Friedberg A.H, Insel A.J. and Spence L, “Linear Algebra”, Prentice Hall of India, New Delhi, 2004.
2. Taha, H.A., “Operations Research – An Introduction”, Sixth Edition, Prentice-Hall of India, New Delhi.
3. Gupta, P.K. and Hira, D.S., “Operations Research”, S.Chand& Co. New Delhi.
4. Peebles Jr., P.Z., “Probability, Random Variables and Random Signal Principles”, McGraw-Hill Inc.
5. Gross, D., Shortie, J.F., Thompson, J.M and Harris, C.M., “Fundamentals of Queueing Theory”, 4th Edition, Wiley,2014.

NT4501 QUANTUM MECHANICS IN NANOSTRUCTURES 3 0 0 3

AIM: To learn the basics of quantum physics and study the behavior of matter at small scale. To understand and develop mathematical derivation of quantum systems for nanostructures.

OBJECTIVE: The objective of this course is to understand the basic concepts of quantum mechanics, wave function, wave equations, operators, and dual nature of matter. How the properties of macroscopic objects change in the microscopic level. The student will analyze the interaction between atoms and elementary particles, electronic phenomena at Nano structures and advanced nano devices.

COURSE OUTCOMES:

Subject Code: **NT4501** Subject Name: **QUANTUM MECHANICS IN NANOSTRUCTURES**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	A proper understanding on the basics of quantum mechanics with fundamental concepts	R, U
CO-02	Students will gain knowledge on the wave equation and uses of wave equation for nanotechnology	U, An, A
CO-03	Understand clearly the quantum mechanical effect of atom and molecules	U, An, A
CO-04	Students can understand the quantum mechanical electrical behavior of materials	U, An, A
CO-05	Understand the various applications of quantum concept in devices which used to make MEMS and NEMS	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT – I QUANTUM PHYSICS 9

Basic principles of quantum mechanics - blackbody radiation – photoelectric effect - dual nature of matter - de Broglie concept - postulates of quantum mechanics - Uncertainty principle, wave function, physical interpretation of wave function – normalized and orthogonal wave functions.

UNIT – II WAVE EQUATION 9

Schrodinger equations: Time dependent, time independent – Solution for Schrodinger equations - Schrodinger equation for many particle systems - periodic boundary conditions – particle in

box one dimension, three dimension – Infinite square well potential, finite square well potential – tunnel effect
- potential step function - reflection and transmission from a potential barrier.

UNIT – III QUANTUM MECHANICS OF ATOMS AND MOLECULES 9

Hamiltonian and Wave functions for Many-particle systems –Multi electron system – Orbital approximation for multielectron atoms – He atom - Pauli‟s Anti-symmetry principle – Born – Oppenheimer approximation. Molecular orbital Theory – LCAO - Theory of H_2 molecule – H^+ - Term Symbols.

UNIT – IV ELECTRONIC PHENOMENON IN NANOSTRUCTURES 9

Electronic energy states in quantum confined systems (OD, 1D, 2D and 3D) - semiconductor hetero junctions - 2-Dimesional Electron Gas (2-DEG) systems – quantum wells, quantum wires and quantum dots - electronic states in quantum dots.

UNIT – V MODERN APPLICATION OF QUANTUM MECHANICS 9

Quantum computing – Quantum Capacitance –organic LEDs, organic FETs, Carbon Nanotube and Grapheme based FETs, Silicon nanowire-based FETs– Spintronics based devices: spin tunneling devices, magnetic sensors, Giant Magnetic Resistance (GMR).

TOTAL: 45 HOURS

TEXT BOOKS:

1. S. Schiff, Quantum Mechanics, McGraw HiIl, 1968.
2. P.M. Mathews and K.Venkatesan, A textbook of Quantum Mechanics, Tata McGraw Hill Publishing Company Ltd.
3. Sathya Prakash and Swati Saluja, Quantum Mechanics, KedarNath Ram Nath& Co.
4. Arthur Beiser, Shoobhit Mahajan and R Rai Choudary, Concepts of Modern Physics, Tata McGraw Hill Education Private Ltd.

REFERENCE BOOKS:

1. K. Gosh, P. Glosekotter and J. Dienstuhl, Nanoelectronics& Nano Systems, Springer Interaction Edition.
2. George W. Hanson, Fundamentals of Nanoelectronics, Pearson, 2011.

NT4502 FUNDAMENTALS OF NANOSCIENCE AND TECHNOLOGY 3 0 0 3

AIM: This paper aims at equipping the students with the basic concepts and principles of Nanoscience and Technology and aware of various applications. To understand how the properties changes with respect to various size and shape of nanomaterial and structure.

COURSE OUTCOMES:

Subject Code: **NT4502** Subject Name: **FUNDAMENTALS OF NANOSCIENCE AND TECHNOLOGY**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Understanding on the basics of nanotechnology with limitation of scale for various dimension	R, U
CO-02	Students will gain knowledge on the nanoscale materials with its own properties	U, An, A
CO-03	Understand clearly the electrical and magnetic properties of nanomaterials	U, An, A
CO-04	Students can understand the properties and future of nanomaterials	U, An, A
CO-05	Understand the various applications of nanomaterials which used to make MEMS and NEMS	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	M	S	M	M	S
CO-02	S	M	S	M	M	S
CO-03	S	M	S	M	M	S
CO-04	S	M	S	M	M	S
CO-05	S	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT – I BASICS AND SCALE OF NANOTECHNOLOGY 9

Introduction – Scientific revolutions –Time and length scale in structures - Dimensionality and size dependent phenomena – Surface to Volume Ratio -Fraction of surface atoms – Surface energy and surface stress- Effect on the Lattice Parameter – Moors law – Quantum Confinement – theory - Classification based on dimensionality – Quantum Dots, Wells and Wires - Opportunities at Nanoscale.

UNIT – II NANOSCALE MATERIALS 9

Nanometer-Scale Metals: Nanogold and Nanosilver– Nanocarbons: Carbon Nanotubes, Bucky ball and Graphene – Nanocomposites- Nanopolymers – Nano ceramics – Clusters: ionic, semiconducting and metallic – Self Assembled Structures – Meso-porous materials - Biologically inspired nanomaterials.

UNIT – III ELECTRONIC AND MAGNETIC PROPERTIES 9

Electronics and Optoelectronics: Quantum Confinement of Superlattices and Quantum Wells – Excitonic Binding and Recombination Energies – Capacitance in a Nanoparticle – Magnetism: Magnetic Moment in clusters/Nanoparticles – Magnetic Order – coercivity – Magnetocrystalline Anisotropy – thermal activation and Superparamagnetic effects.

UNIT – IV PROPERTIES & FEATURES 9

Diffusion in grain boundaries of Metals and Nanocrystalline Ceramics – Red Shift and Surface Plasmon – Reactivity of nanoparticles – Hardness and Super plasticity – curvature effects in nanocrystals – Precipitation - Gibbs-Thomson effect – Thermal expansion and Phase transformation.

UNIT – V APPLICATIONS 9

Renewable energy: Solar energy conversion and catalysis - Photovoltaic diodes - Energy storage - High energy density batteries - Nanomaterials for Data storage. Displays and other devices: Light Emitting Diodes, OLED displays – White lasers.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Horst Hahn, Anatoli Sidorenko, Ion Tiginyanu (Editors), Nanoscale Phenomena Fundamentals and Applications.
2. Nano the essentials: Understanding nanoscience and Nanotechnology, T. Pradeep, Tata McGraw-Hill Publishing Company Limited, NEW DELHI, 2007.
3. An Introduction to Nanoscience and Nanotechnology, Alain Nouailhat, Antony Rowe Ltd, Chippenham, Wiltshire, 2006.

NT4503 SYNTHESIS OF NANOMATERIALS 3 0 0 3

Objective: The objective of the subject is to make knowledge to synthesis the nanomaterials for various field of applications. To understand the limitations and condition to synthesis the nanomaterials.

COURSE OUTCOMES:

Subject Code: **NT4503** Subject Name: **SYNTHESIS OF NANOMATERIALS**		
Course Outcome - COs		**Cognitive Skill**
CO-01	To understanding the basics of nucleation growth of nanomaterials with various types	R, U
CO-02	Students will gain knowledge on solid state method to synthesis the nanomaterials	U, An, A
CO-03	Understand clearly the various chemical method used to synthesis the nanomaterials	U, An, A
CO-04	Students can understand the basics and synthesis of nano porous materials	U, An, A
CO-05	Understand the kinetically confined synthesis of nanoparticles with limitations and conditions	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT –I SPECIFIC FEATURES OF NANOSCALE GROWTH 9

Thermodynamics of Phase Transitions – fundamentals of nucleation growth – Controlling Nucleation & Growth – Size Control of the Nanometric State –Aggregation – Stability of Colloidal Dispersions – Spontaneous Condensation of Nanoparticles: Homogeneous Nucleation – Spinodal decomposition – Nanoparticles‟ morphology.

UNIT –II SOLID STATE METHOD 9

High energy milling – Mechanical milling – Oven techniques – Melt and Mixing – Chimie Douce method – High pressure method – Severe plastic deformation (ECAP & Torsion) – Etching Techniques.

UNIT –III CHEMICAL METHOD 9

Redox method, polyol, solvothermal, hydrothermal, microwave, precipitation, spray pyrolysis, Sol- gel, Gel combustion, aerogel, xerogel, cryogel.

UNIT –IV NANOPOROUS MATERIALS 9

Zeolites, mesoporous materials, nanomembranes – Activated carbon - Carbon nanotubes and graphene - Core shell and hybrid nanocomposites – cell membrane.

UNIT –VKINETICALLY CONFINED SYNTHESISOFNANOPARTICLES 9

Synthesis inside micelles or using microemulsions - Aerosol synthesis - Growth termination - Spray pyrolysis - Template-based synthesis - Epitaxial Core-Shell Nanoparticle.

.

TOTAL: 45 HOURS

REFERENCE BOOKS

1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
2. W. Gaddand, D. Brenner, S. Lysherski and G.J. Infrate(Eds.), Handbook of Nano Science, Engg. and Technology, CRC Press, 2002.
3. K. Barriham, D.D. Vedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004.

NT4571 SYNTHESIS AND PREPARATION OF NANOMATERIALS LABORATORY

0 1 2 2

Objective: The objective of the subject is to make knowledge to synthesis the nanomaterials for various field of applications. To understand the limitations and condition to synthesis the nanomaterials.

COURSE OUTCOMES:

Subject Code: **NT4571** Subject Name: **SYNTHESIS AND PREPARATION OF NANOMATERIALS LABORATORY**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Describe the various types of methods available for nanomaterial synthesis	R, U
CO-02	Explain the concepts in the formation of nanoparticles	U, An, A
CO-03	Explain the template and powder synthesis of nanomaterials	U, An, A
CO-04	Understand the methods in the synthesis of mesoporous and carbon allotropes	U, An, A
CO-05	Understand the evaporation and condensation methods of nanomaterial synthesis	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

1. Synthesis of Gold Nanoparticles by Wet Chemical Method
2. Biosynthesis of Eco-Friendly Silver Nanoparticles
3. Synthesis of Zinc Sulfide Nanoparticles by Reverse Micelle Method
4. Synthesis of Fluorescent Carbon Nanoparticles from Candle Soot
5. Synthesis of Zinc Oxide Nanorods by Microwave Method
6. Synthesis of Bimetallic Nanoparticles by Wet Chemical Methods
7. Preparation of aqueous Ferro fluid.
8. Synthesis of ZnO nanoparticles by gel combustion method.

9. Preparation of Cu nanoparticles by Polyol method.
10. Preparation of metal oxide by molten flux method.
11. Controlled Synthesis of CuO Nanorods.

REFERENCE BOOKS:

1. A Laboratory Course in Nanoscience and Nanotechnology, Dr. Gérrard Eddy Jai Poinern, Murdoch University Perth, Western Australia, CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, 2015.
2. Preparation and Properties of an Aqueous Ferrofluid, Journal of Chemical Education, Vol. 76 No. 7 July 1999.
3. Controlled Synthesis of Nanomaterials at the Undergraduate, Laboratory: $Cu(OH)_2$ and CuO Nanowires, Anderson G. M. da Silva, Thenner S. Rodrigues, André L. A. Parussulo, Eduardo
   G. Candido, Rafael S. Geonmonond, Hermi F. Brito, Henrique E. Toma, and Pedro H. C. Camargo, J. Chem. Educ., DOI: 10.1021/acs.jchemed.6b00185

SEMESTER II

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT4504	Instrumental Methods of Analysis	3	0	0	3
2.	NT4505	Nanoelectronics and Sensors	3	0	0	3
3.	NT4506	Advanced Engineering Materials	3	1	0	4
4.	NT4507	Biological Nanostructures	3	0	0	3
5.	NT45XX	Department Elective III	3	0	0	3
6.	NT45XX	Department Elective IV	3	0	0	3
PRACTICAL						
7.	NT4572	Characterization of Nanomaterials Laboratory	0	1	2	2
	NT45P1	Internship	0	0	1	1
TOTAL			**18**	**2**	**2**	**22**

NT4504 INSTRUMENTAL METHODS OF ANALYSIS 3 0 0 3

OBJECTIVE:

To make the students understand the working principles of different types of instruments and their applications.

COURSE OUTCOMES:

Subject Code: **NT4504** Subject Name: **INSTRUMENTAL METHODS OF ANALYSIS**

Course Outcome - COs		Cognitive Skill
CO-01	Understanding the principles and procedures of spectroscopy and applying them to identify specific nanomaterials	R, U
CO-02	Understanding microscopy and applying the techniques to characterize the morphology and techniques of different microscopes	U, An, A
CO-03	Understanding the instrumentation and principles of equipment used to measure temperature tolerance and crystal size.	U, An, A
CO-04	MR spectroscopy and mass spectrometer to identify specific structures, chemical makeup, functional groups, molecular framework and Instrumentation	U, An, A
CO-05	To understand the electrical and electronic behavior of synthesized nanomaterials and their instrumentation.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT –I SPECTROSCOPY 9

Electromagnetic Radiation – Electromagnetic Spectrum – Atomic Energy Levels – Molecular Electronic Energy Levels – Vibrational Energy Levels – Lambert-Beer‟s Law – Radiation Sources – Sample Containers – Wavelength Selection – Detectors – Instrumentation, Applications, Theory of Ultraviolet-Visible and Atomic Absorption Spectroscopy – Instrumentation, Applications, Theory of Fluorescence and Phosphorescence – Instrumentation, Applications, Theory of Infrared Spectrometry – Instrumentation, Applications, Theory of Raman Spectroscopy.

UNIT II X-RAY ANALYTICAL METHODS 9

Introduction - X-ray emission theory - X-ray fluorescence spectrometry - X-ray fluorescence working principles - X-ray fluorescence spectrometer set-up - Interpretation of XRF spectra - Energy dispersive X-ray fluorescence (EDXRF) - Particle induced X-ray emission (PIXE) spectrometry - Development of PIXE analytical technique - Ion beam analysis (IBA) principles - PIXE analysis - X- ray diffraction technique - Diffraction and Bragg‟s Law - X-ray diffractometer set-up.

UNIT –III THERMAL ANALYSIS AND SCATTERING TECHNIQUES 9

Principle and Instrumentation of: Thermogravimetry – Differential Scanning Calorimetry and Differential Analysis – Evolved Gas Detection and Analysis – Thermomechanical Analysis – Principle and Instrumentation – Dynamic Light Scattering (DLS) – Zeta Potential Analysis.

UNIT –IV MAGNETIC RESONANCE SPECTROSCOPY AND MASS SPECTROMETRY9

Principles of Nuclear Magnetic Resonance spectrophotometer (NMR) – Continuous wave and Pulsed Fourier Transform NMR – Spectra and Molecular Structure: chemical shifts, Spin-Spin Coupling – Applications of ^{1}H and ^{13}C NMR – Molecular Mass Spectra – Ionization Methods – Mass Analysers – Ion-Collection Systems – Correlation of Mass Spectra with Molecular Structure – Quantitative Analysis – Instrumentation, Applications, Theory of Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

UNIT – V MICROSCOPY **9**

Principle and Instrumentation of: Scanning Electron Microscopy (SEM) – Transmission Electron Microscopy (TEM) – Sample Preparation – Modes of Operation – Scanning Tunnelling Microscope (STM) – Atomic Force Microscope (AFM) (Contact and non contact), Magnetic Force Microscopy (MFM), Field Ion Microscope (FIM).

TOTAL: 45 HOURS

TEXT BOOKS:

1. Willard, H. H. (2012). Instrumental methods of analysis. 7th Ed., New Delhi: CBS.
2. Skoog, D. A. (2007). Principles of instrumental analysis. Saunders College Pub.
3. Kumar, N., &Kumbhat, S. (2016). Essentials in nanoscience and nanotechnology. Hoboken, New Jersey : Wiley.
4. Igwebike-Ossi, C.D., 2017. X-ray techniques. Failure analysis and prevention, 10.

REFERENCE BOOKS:

1. Murty, B. S., Shankar, P., Raj, B., Rath, B. B., &Murday, J. (2013). Textbook of Nanoscience and Nanotechnology. Berlin, Heidelberg: Springer.
2. Braun, R. D. (2014). Introduction to instrumental analysis. India: BS Pubications.
3. Sharma, B. K. (2000). Instrumental methods of chemical analysis (analytical chemistry). India: GOEL Publishing House.
4. Skoog, D. A., West, D. M., & Holler, F. J. (1992). Fundamentals of analytical chemistry. Fort Worth, Tex: Saunders College Pub.

NT4505 NANOELECTRONICS AND SENSORS 3 0 0 3

PREREQUISITE: Basic microelectronic technologies and of electronic devices. Basic principles of organic chemistry and sensing.

AIM: To understand the principle and working of various nanoelectronic devices and sensors.

OBJECTIVE: The objective of this course is to be familiar with the quantum mechanics for nanodevices. Using these new concepts, the student will be able to understand the principles of the design, the simulation and the fabrication of nanostructures for electronic devices and sensors.

COURSE OUTCOMES:

Subject Code: **NT4505** Subject Name: **NANOELECTRONICS AND SENSORS**		
Course Outcome - COs		**Cognitive Skill**
CO-01	To study the fundamental of semiconductor and nanoelectronics and its working.	R, U
CO-02	To understand the principle and operation of nano electronics devices.	U, An, A
CO-03	To know the characteristics of sensors.	U, An, A
CO-04	To study the working and principle of physical and chemical sensors.	U, An, A
CO-05	To study the wireless sensor networks and architecture.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT –I: FUNDAMENTALS OF NANOELECTRONICS 9

Electronic properties of semiconductors - density of carriers in intrinsic and extrinsic semiconductors. Consequence of heavy doping, conduction processes in semiconductors, electron- hole pair formation and recombination. PN junction, carrier recombination and diffusion, injection efficiency, heterojunction, double heterojunction, quantum well, quantum dot and super lattices.

UNIT –II: NANOELECTRONIC DEVICES 9

Resonant-tunnelling diodes, Field-effect transistors, Single-electron-transfer devices, Potential-effect transistors, Light-emitting diodes and lasers, Nano-electromechanical system devices.

UNIT –III: CHARACTERISTICS &PHYSICO-CHEMICAL SENSORS 9

Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, calibration and standard, selectivity, sensitivity, reproducibility, detection limits, response time. Criteria for the choice of materials for sensors, Temperature sensors, electromagnetic sensors, Chemical sensors - Optical and radiation sensors, measurement of gas sensing property, Gas sensors based on semiconductor devices.

UNIT –IV: NANOTECHNOLOGY ENABLED WIRELESS SENSORS 9

Introduction to Wireless Sensor Networks - Possibilities - Realities – Applications - Node Architecture - Sensor Networks Architecture - Radio Options for the Physical Layer - Future Developments

UNIT-V: INDUSTRIAL APPLICATIONS OF SENSORS 9

Infrared and thermal sensors, such as Bragg gratings, thin films, and microbolometers- Gas and bio sensors, Surface Acoustic Wave (SAW) devices, acoustic imaging, home monitoring of elderly people - Piezoresistive, wireless, and electrical sensors for health monitoring - Wearable PTF Strain Sensors.

TOTAL: 45 HOURS

TEXT BOOKS

1. Mitin, V. V., Kochelap, V. A., &Stroscio, M. A. (2008). *Introduction to nanoelectronics: Science, nanotechnology, engineering, and applications*. Cambridge: Cambridge University Press.
2. Cunningham, A. J. (1998). *Introduction to bioanalytical sensors*. New York: Wiley.
3. Webster, J. G. (1999). *The measurement, instrumentation, and sensors handbook*. Boca Raton, Fla: CRC Press published in cooperation with IEEE Press.
4. Krzysztof Iniewski, Smart sensors for industrial applications, Series: Devices, circuits, and systems, Publisher: CRC Press Taylor & Francis
5. Chong-Min Kyung, HirotoYasuura, Yongpan Liu, Youn-Long Lin (eds.), Smart Sensors and Systems: Innovations for Medical, Environmental, and IoT Applications, Publisher: Springer International Publishing, Year: 2017, ISBN: 978-3-319 33201-7,978-3-319-33200-0

REFERENCES

1. Poole, C. P., & Owens, F. J. (2003). *Introduction to nanotechnology*. Hoboken, NJ: J. Wiley.
2. Dupas, C., Houdy, P., Lahmani, M., & European Materials Research Society. (2007). *Nanoscience: Nanotechnologies and nanophysics*. Berlin: Springer.
3. Patranabis, D. (2004). *Sensors and transducers*. New Delhi: Prentice-Hall of India.
4. Cooper, W. D. (1978). *Electronic instrumentation and measurement techniques*. Englewood Cliffs, N.J: Prentice-Hall.
5. N. S. Lawand, P. J. French, J. van Driel (auth.), Alex Mason, Subhas Chandra Mukhopadhyay, Krishanthi Padmaran iJayasundera, Nabarun Bhattacharyya (eds.) (2014) Sensing Technology: Current Status and Future Trends II, Smart Sensors, Measurement and Instrumentation 8, Springer International Publishing. ISBN: 978-3-319-02314-4, 978-3-319-

02315-1.

NT4506 ADVANCED ENGINEERING MATERIALS 3 1 0 4

AIM: To introduce the knowledge on engineering materials with its classifications, properties and applications.

OBJECTIVE: To make the students understand different processing methods of preparation of engineering materials and impart knowledge on properties and applications of above materials.

COURSE OUTCOMES:

Subject Code: **NT4506** Subject Name: **ADVANCED ENGINEERING MATERIALS**		
Course Outcome - COs		**Cognitive Skill**
CO-01	To study the fundamental of semiconductor and nanoelectronics and its working.	R, U
CO-02	To understand the principle and operation of nano electronics devices.	U, An, A
CO-03	To know the characteristics of sensors.	U, An, A
CO-04	To study the working and principle of physical and chemical sensors.	U, An, A
CO-05	To study the wireless sensor networks and architecture.	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT –I INTRODUCTION TO ENGINEERING MATERIALS 9

Classification of engineering materials: Metals and Alloys, Ceramics and Glasses, Polymers and Composites – Properties of engineering materials: physical and chemical properties, mechanical and dimensional properties, thermal properties, environmental properties and electrical properties.

UNIT – II METALS AND ALLOYS 9

Ferrous Alloys: Heat Treatments – Selective and Surface – Hardening, Specifications – Low Alloy and High Alloy Steels, Tool Steels, Stainless Steels, Cast irons.

Non-ferrous Alloys: Copper and its alloys, Aluminum and its alloys, Nickel, Zinc, Titanium and its alloys, Magnesium and Refractory Metals.

UNIT –III CERAMICS AND GLASSES 9

Ceramic processing: powder processing, milling techniques and sintering techniques – Structural ceramics: Oxide ceramics, carbide ceramics and nitride ceramics – Electronic ceramics: Ceramic insulators and capacitors – Refractory ceramics: Silica, alumina, carbide based and nitride based refractories – Glasses: Glass forming processes – glass composition, heat treatment schedule, crystal nucleation in glass, nucleation agent – high purity silica glass, laser glasses, fiber glasses, optical glasses, fiber glass, non-oxide glasses.

UNIT –V POLYMERS 9

Classification of polymers – synthesis of polymers: step growth polymerization, chain growth polymerization, polymerization techniques – properties of polymers: mechanical thermal and electrical – applications: conductive polymers-bio polymers-liquid crystal polymers-photonic polymers-high temperature polymers.

UNIT –IV MATRIX COMPOSITES 9

Types of composite materials – the concept of load transfer – matrix materials - Metallic Materials and Metal Matrix Composites: Aluminium Alloys, Titanium Alloys, Superalloys - Ceramic Materials and Ceramic Matrix Composites: Non-Oxide Materials,Silicon Nitride Matrix Composites, Fracture and Fatigue-Oxide Materials - Polymer Matrix Composites: Quasi-Static Strength -Fatigue Strength.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Engineering Design: A Materials and Processing Approach by George Ellwood Dieter, McGraw-Hill, 2000.
2. D.W.Richerson. Modern Ceramic Engineering: Properties, Processing and Use in Design.Taylor and Francis Group, New York, 2005.
3. Lewis, M.H., Glasses and Glass Ceramics, Chapman and Hall, London, 1992.
4. Louis A. Pilato· Michael J. Michno, Advanced Composite Materials, Springer-Verlag Berlin Heidelberg GmbH.
5. Joel R.Fried, Polymer Science and Technology, Phi Learning Pvt. Ltd., 2009.
6. V.R. Gowarikar, N.V.Viswanathan&J.Sreedhar, Polymer Science, New Age International, 2011.
7. Materials Research and EngineeringEdited by B. llschner and K. C. Russell, AdvancedAerospace Materials, Springer-Verlag, ISBN 978-3-64250161-6 ISBN 978-3-642-50159-3 (eBook)DOl 10.1007/978-3-642-50159-3

NT4507 BIOLOGICAL NANOSTRUCTURES 3 0 0 3

OBJECTIVES:

- Impart knowledge on the nanostructures and nanoscale phenomenon in cells.
- To understand the different three-dimensional DNA nanostructures and their uses.
- Familiarize the concepts involved in protein corona with reference to protein nanoparticlesand enzyme nanotechnology.

COURSE OUTCOMES:

Subject Code: **NT4507** Subject Name: BIOLOGICAL NANOSTRUCTURES		
Course Outcome - COs		**Cognitive Skill**
CO-01	Impart knowledge on the nanostructures and nanoscale phenomenon in cells.	R, U
CO-02	To understand the different three-dimensional DNA nanostructures and their uses.	U, An, A
CO-03	Familiarize the concepts involved in protein corona with reference to protein nanoparticles and enzyme nanotechnology.	U, An, A
CO-04	Acquaint with the glyco-metal, glyco-carbon nanoparticles and their fate.	U, An, A
CO-05	Explain the synthesis and applications of lipid-based nanostructures	U, An, A

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis0

- **Mapping of Course Outcome with Programme Outcome**

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: CELLULAR NANOSTRUCTURES 12

Cellular elements in developing functional nanostructures and nanomaterials– Nanopatterning – Cytoskeletal nanomechanics – Bacterial and viral nanostructured materials – Plant-derived nanostructures: types, evolution and applications – Phytochemicals in the genesis of nanoparticles.

UNIT II: DNA NANOARCHITECTURE 12

Genome structure and organization in prokaryotes and eukaryotes - Structure and function of nucleic acids – The Central Dogma of life – DNA tile assembly, brick

assembly, 3D DNA nanostructures – Organic and inorganic DNA nanostructures – DNA aptamer and DNA origami –DNA varieties: A, B, and Z – Applications of DNA nanostructures.

UNIT III: PROTEIN AND ENZYME NANOPARTICLES 12

Proteins: Structure, classification and functions – Protein nanoparticles: Designing, synthesis strategy, ligands used and their applications – Enzymes and Enzyme nanoparticles: properties, structure: Preparation, immobilization, kinetic properties and applications of enzyme nanoparticles in day-day to life– Synzymes, ribozymes.

UNIT IV: CARBOHYDRATESAND GLYCO NANOPARTICLES 12

Properties and Function of Carbohydrates– Sugars: disaccharides, trioses, tetroses, pentoses, hexoses – Stereoisomers - Aminosugars, phosphosugars, sugar derivatives, deoxysugars – Oligosaccharides –Polysaccharides - Homo and hetero polysaccharides, amylose, amylopectin, dextrans – starch –Glycogen: synthesis and degradation-glycolysis, TCA cycle, glycosyl moieties, cell wall polysaccharides – cellulose, chitin; Preparation of glyconanoparticles – Applications.

UNIT V: LIPIDSAND LIPID BASED NANOPARTICLES 12

Structure, function and significance of lipids and membrane transport– Membranous nanostructures and their role in cellular traffic –Different types of lipid nanostructures: Preparation, applications – Lipid-based nanomaterials-Lipid-polymer nanoparticles and solid lipid nanoparticles–.

TOTAL: 60 PERIODS

REFERENCES:

1. Barnard, Amanda S., and HaiboGuo, eds. Nature's Nanostructures. CRC Press, US, 2012.
2. Stroscio MA and Dutta M, Biological nanostructures and applications of nanostructures in biology: Electrical, Mechanical and Optical properties. Kluwer academic publishers New York, 2004.
3. Iglič, Aleš, Damjana Drobne, and VeronikaKralj-Iglic. Nanostructures in biological systems: theory and applications. CRC Press, US, 2015.
4. Mendes, Paula M., Chun L. Yeung, and Jon A. Preece. "Bio-nanopatterning of surfaces." Nanoscale research letters 2.8 (2007): 373-384.
5. Häfeli, U. O., R. Arshady, and K. Kono. "Smart Nanoparticles in Nanomedicine-the MML Series." (2006): 77.
6. Durán, Nelson, et al. "Mechanistic aspects in the biogenic synthesis of extracellular metal nanoparticles by peptides, bacteria, fungi, and plants." Applied microbiology and biotechnology 90.5 (2011): 1609-1624.
7. Lehninger, Principles of Biochemistry, 5th edition, David L Nelson; Michael M Cox. W.H. Freeman Publishers, New York, 2012.
8. E.D.P.DeRobertis, Cell & Molecular Biology, 8th edition, Lippincott publishers, 2010.

9. Lewin Benjamin, Genes, 9th edition, CBS Publishers and Distributors, 2007
10. Yonggang Ki, 3D DNA Nanostructure, Humana Press Inc., New York, 2015.
11. Bujold, Katherine E., AurélieLacroix, and Hanadi F. Sleiman. "DNA nanostructures at theinterface with biology." Chem 4.3 (2018): 495-521.
12. Nanomechanical Devices Based on DNA, Christof M. Niemeyer and Michael Adler, Angew.Chem. Int. Ed. 2002, 41, No. 20, 3779-83
13. Hawkins, Michael J., Patrick Soon-Shiong, and Neil Desai. "Protein nanoparticles as drugcarriers in clinical medicine." Advanced drug delivery reviews 60.8 (2008): 876-885.
14. Pundir, Chandra S. Enzyme nanoparticles: preparation, characterization, properties andapplications. William Andrew, UK, 2015.
15. Carlos Aelman, Peptide Materials: From Nanostuctures to Applications, Wiley UK, 2013.
16. Luigi Sasso, Self-Assembled Peptide Nanostructures: Advances and Applications inNanobiotechnology. Pan Stanford Publishing, US, 2012.
17. Keith J. Stine, Carbohydrate Nanotechnology, Wiley, New Jersey, 2015.
18. Reichardt, Niels C., Manuel Martín-Lomas, and Soledad Penadés."Glyconanotechnology." Chemical Society Reviews 42.10 (2013): 4358-
4376.
19. Tresset, Guillaume. "The multiple faces of self-assembled lipidic systems." PMCbiophysics 2.1 (2009): 1-25.
20. Gordillo-Galeano, Aldemar, and Claudia Elizabeth Mora-Huertas. "Solid lipid nanoparticlesand nanostructured lipid carriers: A review emphasizing on particle structure and drugrelease." European Journal of Pharmaceutics and Biopharmaceutics 133 (2018): 285-308.
https://nptel.ac.in/courses/118/106/118106019/

NT4572 CHARACTERIZATION OF NANOMATERIALS LABORATORY 0 1 2 2

AIM: To analyze the characteristics of nanomaterials using characterization techniques.

OBJECTIVE: The objective of this course is to analyze the characteristic properties of nanomaterials like morphology, thermal, chemical, structural, optical, electrical, mechanical properties etc that forms the important criterion for their application.

COURSE OUTCOMES:

Subject Code: **NT4572** Subject Name: **CHARACTERIZATION OF NANOMATERIALS LABORATORY**		
Course Outcome - COs		**Cognitive Skill**
CO-01	To learn and understand the physics behind variousnano characterization tools	R, U
CO-02	To understand the interaction of electromagnetic radiation with matter using various spectroscopic techniques.	U, An, A
CO-03	To understand the mechanism behind the surface morphological techniques and surface conductivity.	U, An, A
CO-04	To learn the instrumental techniques to measure particle size, surface area, porosity, and contact angle.	U, An, A
CO-05	To apply physical and chemical methodologies to measure thermal and mechanical properties of materials.	U, An, A

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis
- **Mapping of Course Outcome with Programme Outcome**

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

1. Particle size – Microscopy, Centrifugal Sedimentation, Dynamic Light Scattering
2. Identification and Quantification of compounds – UV-Vis Spectroscopy
3. Identification of chemical bonds – FTIR
4. Thermal analysis – Differential Scanning Calorimeter
5. Crystallinity – X-Ray Diffraction
6. Surface area – Surface Area Analyzer
7. Nanofilm - Interferometry
8. Energy studies – Potentiostat

9. Contact angle – Goniometer
10. Fluorescence – Spectrofluorometer
11. Porosity – Porosimeter
12. Mechanical property – Universal Testing Machine
13. Morphology – SEM/AFM/TEM
14. Conductivity – STM

SEMESTER III

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT45XX	Department Elective	3	0	0	3
2.	OEC	Open Elective (Industrial Safety / Operation Research)	3	0	0	3
3.		Audit (Disaster Management / English for Research Paper Writing)	2	0	0	0
PRACTICAL						
4.	NT45P1	Project work – Phase I	0	0	12	6
TOTAL			**8**	**0**	**12**	**12**

SEMESTER IV

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	NT45P2	Project work – Phase II	0	0	32	16
TOTAL			0	0	32	16

Total Credit 70

LIST OF ELECTIVES

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	NT45A1	Carbon Based Nanostructures	3	0	0	3
2.	NT45A2	Physics And Chemistry of Nanomaterials	3	0	0	3
3.	NT45A3	Drug Delivery Systems	3	0	0	3
4.	NT45A4	Polymer Science And Technology	3	0	0	3
5.	NT45A5	Biophysics	3	0	0	3
6.	NT45A6	Vacuum Science And Cryogenics	3	0	0	3
7.	NT45A7	Introduction to Optics, Lasers and Photonics	3	0	0	3
8.	NT45A8	Lithography and MEMS	3	0	0	3

9.	NT45A9	Semiconductor Based Electronic Devices	3	0	0	3
10.	NT45B1	Advanced Nanoelectronics Based Devices and Circuits	3	0	0	3
11.	NT45B2	Research Methodology and IPR	3	0	0	3
12.	NT45B3	Nanotoxicology	3	0	0	3

SEMESTER III

Open elective

1. GE35A1	Business Analytics	3 0 0 3
2. GE35A2	Industrial Safety	3 0 0 3
3. GE35A3	Operations Research	3 0 0 3
4. GE35A4	Cost Management of Engineering Projects	3 0 0 3
5. GE35A5	Composite Materials	3 0 0 3
6. GE35A6	Waste to Energy	3 0 0 3

Audit course

1. English for Research Paper Writing
2. Disaster Management
3. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

LIST OF DEPARTMENT ELECTIVES

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	NT45A1	Carbon Based Nanostructures	3	0	0	3
2.	NT45A2	Advanced Drug Delivery Systems	3	0	0	3
3.	NT45A3	Polymer Nanocomposites	3	0	0	3
4.	NT45A4	Nanotechnology in Healthcare	3	0	0	3
5.	NT45A5	Introduction to Optics, Lasers and Photonics	3	0	0	3
6.	NT45A6	Lithography and MEMS	3	0	0	3
7.	NT45A7	Semiconductor Based Electronic Devices	3	0	0	3
8.	NT45A8	Advanced Nanoelectronic Based Devices and Circuits	3	0	0	3
9.	NT45A9	Research Methodology and IPR	3	0	0	3
10.	NT45B1	Nanotoxicology	3	0	0	3
11.	NT45B2	Nanomaterials for Energy and environment	3	0	0	3
12.	NT45B3	Internet of Things and Cloud computing	3	0	0	3

NT45A1 CARBON BASED NANOSTRUCTURES 3 0 0 3

Prerequisite: Nanotechnology

Aim: To study the various carbon nanomaterials and their properties

Objective:

1. To understand the mechanism behind the formation of carbon allotropes and its preparation techniques.
2. To find the possible application using various carbon allotropes.

Subject Code: NT45A1 Subject Name: **CARBON BASED NANOSTRUCTURES**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Study, understand various carbon materials and their chemical nature, electronic configuration.	U, A
CO-02	Understand the structure of fullerenes and various synthesis methods.	U
CO-03	Analyze and study the concepts single-walled carbon nanotubes and multiwalled carbon nanotubes and Structure.	An
CO-04	Study and remember the basic concept Graphene Oxide structure and properties.	R, U
CO-05	Study the applications of all carbon based nanomaterials.	An, E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO- C	PO-D	PO- E	PO- F	PO-G	PO-H
CO-01	S	S	S	M	N	M	M	S
CO-02	M	N	S	S	S	M	N	L
CO-03	S	L	M	N	N	M	S	N
CO-04	N	M	L	S	L	S	N	S
CO-05	S	S	L	L	N	M	S	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION **9**

Carbon - atomic structure – Different hybridization – Chemical structure and Nature of carbon allotropes: Diamond, Graphite, Graphene, Carbon clusters, Carbon Nanostructures: carbon nanotubes, Diamond like carbon, carbon, and aerogel - porous carbon, activated carbon, carbon black, CNT, Nanotube Peapods and Graphene.

UNIT II: FULLERENES **9**

The structure of fullerenes; Synthesis (CVD and Arc Discharge), and purification of fullerenes; different sized fullerenes - doped fullerenes; Electrical and magnetic properties – electronic structure of fullerene – fullerene functionalization.

UNIT III : CNT **9**

Single-walled carbon nanotubes and Multiwalled carbon nanotubes, Structure – Zigzag, armchair, chiral, single and multiwall CNT - Synthesis and purification of carbon nanotubes: CVD, Arc Discharge, High Pressure Carbon Monoxide, Laser Ablation - mechanism of growth – electron transport – mechanical property – electronic structure of CNT.

UNIT IV: GRAPHENE **9**

Graphene Oxide structure and properties – Hummers method - electronic structure – electron transport –Graphene Oxide Reduction – reduced Graphene Oxide - few layer graphene - Micromechanical Exfoliation – from SiC —Graphene growth on surfaces (CVD) – grapheme &graphene oxide functionalization.

UNIT V: APPLICATIONS 9

Electrode materials for supercapacitors-Graphite-based materials for energy storage applications-Carbon nanotubes (CNTs) and aerogels for hydrogen storage-Advanced materials for thermal protection systems: C-C composites-Fuel cells: Materials and advancements in energy conversion-Structural stability in demanding environments: Carbon fiber composites-Diamond-like films and their applications in abrasives - Sensors and biosensors utilizing graphene and graphene oxides.

T: 15 + L: 45 = TOTAL: 60 PERIODS

TEXT BOOKS

1. Langa, F., Nierengarten, J.-F., & Royal Society of Chemistry (Great Britain). *Fullerenes: Principles and applications*. Cambridge: Royal Society of Chemistry, (2007).
2. Gaponenko, S. V.,*Optical properties of semiconductor nanocrystals*. Cambridge, UK: Cambridge University Press,(1998).
3. Shonaike, G. O., &Advani, S. G.,*Advanced polymeric materials: Structure property*

relationships. Boca Raton, FL: CRC Press, (2003).

REFERENCE BOOKS

1. Dresselhaus, M. S., Dresselhaus, G., &Eklund, P. C., *Science of fullerenes and carbon nanotubes*. San Diego: Academic Press, (1996).
2. Goddard, W. A., *Handbook of nanoscience, engineering, and technology*. Boca Raton: CRC Press, (2003).
3. In Nalwa, H. S., *Nanostructured Materials and Nanotechnology: Concise Edition*. (Referex Mechanical Engineering and Materials.) San Diego: Academic Press [Imprint.] (2001).

NT45A2 ADVANCED DRUG DELIVERY SYSTEMS 3 0 0

3 OBJECTIVES:

- To learn about Fundamentals of drug delivery systems
- To study the materials and techniques used in Delivery systems
- To learn about Recent development in the area of devices and therapy.

COURSE OUTCOMES:

Subject Code: **NT45A2** Subject Name: ADVANCED DRUG DELIVERY SYSTEMS		
Course Outcome - COs		**Cognitive Skill**
CO-01	**Principles:** Understanding the concepts of drugs, their penetration action and delivery for targeting	R, U
CO-02	**Diffusion:** Action of drugs and their possibilities to make the drug more bio available	U, An, A
CO-03	**Permeation:** Mode of drug movement and type of activity noticed in different tissues	U, An, A
CO-04	**Distribution:** Understanding the compartmentalization and stability parameters of drugs	U, An, A
CO-05	**Types of drug delivery**: Advantages of different types of delivery systems available	U, An, A

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: THEORY OF ADVANCED DRUG DELIVERY 9

Fundamentals of Nanocarriers - Size, Surface, Magnetic and Optical Properties, Pharmacokinetics and Pharmacodynamics of Nano drug carriers. Critical Factors in drug delivery. Transport of Nanoparticles - In Vitro and Ex Vivo Models.

UNIT II: POLYMERS 9

Dendrimers- Synthesis -Nanoscale containers- Dendritic Nanoscafold systems- Biocompatibility of Dendrimers, Gene transfection. pH based targeted delivery- chitosan and alginate. Copolymers in targeted drug delivery- PCL, PLA, PLGA.

UNIT III: LIPID BASED NANOCARRIERS 9

Liposomes, niosomes and solid lipid nanoparticles. Ligand based delivery by liposomes. Cubosomes.

UNIT IV: MICROBES AND ANTIBODY BASED NANOCARRIERS 9

Bacterial dependent delivery of vaccines. Drug delivery and subcellular targeting by virus, Drug packaging and drug loading. Delivery of therapeutics by antibodies and antibody bioconjugates.

UNIT V: DEVICES FOR DRUG DELIVERY 9

Fabrication and Applications of Microneedles, Micropumps, microvalves. Implantable microchips.

TOTAL : 45 HOURS

REFERENCES:

1. M. Salzman Drug Delivery: Engineering Principles for Drug Therapy, Oxford University Press, 2001.
2. A.M. Hillery, Drug Delivery and Targeting, CRC Press, 2002.
3. B. Wang, Drug Delivery: Principles and Applications, Wiley Intersceince, 2005.
4. Ram B. Gupta, Uday B. Kompella, Nanoparticle Technology for Drug Delivery, Taylor & Francis, 2006.

NT45A3 POLYMER NANOCOMPOSITES 3 0 0 3

Prerequisite: Nil

Aim: To provide a fundamental understanding on polymers and polymer nanocomposites

Objective: The course is designed to study certain selected topics from the broad area of polymer and polymer nanocomposites, which include various polymer types, synthetic methods and mechanism of formation, polymer characterization, solution properties of polymers, nanocomposites and their application.

COURSE OUTCOMES:

Subject Code: **NT45A3** Subject Name: **POLYMER NANOCOMPOSITES**		
Course Outcome - COs		**Cognitive Skill**
CO-01	Study, understand various Engineering materials.	R, U
CO-02	Understand the structure of metals and alloys.	U, An, A
CO-03	Analyze and study the advanced engineering materials like ceramic and glasses.	U, An, A
CO-04	Study and remember classifications of composites and the polymers.	U, An, A
CO-05	Study the applications of all smart materials.	U, An, A

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO POLYMERS 6

Monomers, Natural and synthetic polymers, glass transition, melting transition, Block and graft polymers. Polymer blends and composites, Rubber and plastics, thermoplastics and thermosets. Biodegradable polymers, biomedical polymers, polymer liquid crystals

UNIT II: SYNTHETIC METHODS AND MECHANISM 12

Different types of polymerizations: addition, condensation and stereo regular

polymerization. Kinetics and mechanism of addition, condensation and stereo regular polymerizations. Co- polymerization - Important techniques of polymerization: emulsion, bulk, solution and suspension.

UNIT III: POLYMER CHARACTERIZATION 9

Solubility and swelling, molecular weight determination by GPC, viscosity, light scattering and Osmometry. Polymer characterizations by IR, NMR, X-ray analysis etc. Thermal analysis of polymers using DSC, TGA, DTA and DMA.

UNIT IV: POLYMER SOLUTIONS 9

Introduction to solution properties of polymers - Thermodynamics of liquid mixtures of small molecules- Entropy and heat of mixing in polymer solutions- Flory-Huggins theory of polymer solutions- Flory-Krigbaum theory and its application to polymer solutions- Cluster type theory in polymer solutions- Understanding polymer solubility and phase behavior- Effects of polymer concentration on solution properties- Polymer-solvent interactions and their impact on solution behavior- Practical applications of polymer solutions in various industries.

UNIT V: NANO COMPOSITES 9

Introduction to composites, Fabrication of Polymer-carbon nanotubes based composites, their mechanical properties, and industrial possibilities. Epoxy nanocomposites, Silicon rubber, organically modified clay, Magnetic polymer nanocomposites, Polymer/graphite nanocomposites, Wear resisting polymer Nanocomposites.

TOTAL : 45 HOURS

Text Books

1. Billmeyer, F. W. (1984). *Textbook of polymer science*. New York: Wiley.
2. Flory, P. J. (1953). *Principles of polymer chemistry*. Ithaca: Cornell University Press.
3. Gowariker, V. R., Viswanathan, N. V., & Sreedhar, J. (1986). *Polymer science*. New York: Wiley.
4. Odian, G. G. (1970). *Principles of polymerization*. New York: McGraw-Hill.

Reference Books

1. McCrum, N. G., Buckley, C. P., & Bucknall, C. B. (1988). *Principles of polymer engineering*. Oxford [Oxfordshire: Oxford University Press.
2. Pinnavaia, T. J., & Beall, G. W. (2000). *Polymer-clay nanocomposites*. Chichester: Wiley.
3. Lazzari, M., Liu, G., & Lecommandoux, S. (2006). *Block copolymers in nanoscience*. Weinheim: Wiley-VCH.
4. Gerdeen, J. C., Lord, H. W., & Rorrer, R. A. L. (2006). *Engineering design with polymers and composites*. Boca Raton: CRC/Taylor & Francis.

NT45A4 NANOTECHNOLOGY IN HEALTH CARE 3 0 0

3 OBJECTIVES

- To be introduced to recent advancements in nano medicine.
- To learn about nano diagnostics.
- To learn developments in nanostructured materials used for medical implants.

COURSE OUTCOMES:

Subject Code: **NT45A4** Subject Name: NANOTECHNOLOGY IN HEALTH CARE		
Course Outcome - COs		**Cognitive Skill**
CO-01	Comprehend the nanoparticles-based gene therapy, nanoprobing and profiling techniques and their application	R, U
CO-02	Understand the use of metal nanoparticles and antibodies in diagnosis of biomarkers with high sensitivity	U, An, A
CO-03	Be aware of the principle and uses of cantilever sensors and imaging of plaques and tumours	U, An, A
CO-04	Completely understand the ocular, cochlear, dental implants and nanofiber technology	U, An, A
CO-05	Have knowledge on functionalised nanoscaffolds, magnetic, organic and inorganic nanoparticles	U, An, A

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: TRENDS IN NANOBIOTECHNOLOGY 9

Nanotechnology in gene therapy. Stem Cell technology. PCR, ELISA, DNA Profiling and Blotting techniques-Nanoprobes.

UNIT II: NANOIMMUNOTECHNOLOGY 9

Nanoimmuno assay and nano-immuno sensors- Bio-Barcode Assay- use of magnets, gold, DNA and antibodies. Immunodiagnostics for cancer and central nervous system disorders.

UNIT III: NANOTECHNOLOGY BASED MEDICAL DIAGNOSTICS9

Improved diagnosis by i*n vivo* imaging - detection of tumors, plaque and genetic defects. Nanobot medical devices. Cantilever Sensors.

UNIT IV: PROSTHETIC AND MEDICAL IMPLANTS 9

Prosthesis and implants. neural, ocular, cochlear, dental implants. implants and prosthesis of skin, limb, bone. Artificial organ and Organ transplant. Nano fibre scaffold technology.

UNIT V: BIOMEDICAL APPLICATIONS OF NANOTECHNOLOGY 9

Nano-bioconjugates and their significance. Nanoscaffolds. Magnetic Nanoparticles. Multifunctional Inorganic and organic nanoparticles and their biomedical applications.

TOTAL : 45 HOURS

REFERENCES:

1. Brian, R Eggins, Chemical Sensors and Biosensors; Wiley; New York, 2002.
2. 2. L Gorton, Biosensors and modern biospecific analytical techniques, Wilson & Wilson‟s Comprehensive Analytical Chemistry Elsevier, Amsterdam, London; 2005.
3. David Wild; The Immunoassay Handbook; 3rd ed.; Amsterdam: Elsevier; 2005.
4. Allen J Bard and Larry R Faulkner; Electrochemical Methods: Fundamentals and Applications; Wiley, NewYork, 2nd ed.; 2001.
5. Vladimir M. Mirsky, Ultrathin Electrochemical Chemo- and Biosensors: Technology andPerformance in Springer Series on Chemical Sensors and Biosensors; Springer, Berlin; 2004

NT45A5 INTRODUCTION TO OPTICS, LASERS AND PHOTONICS 3 0 0 3

Objective:

1. Expose them to the emerging area of nanophotonics and the phenomena involved in such devices.

2. Provide deep understandings of light – matter interaction at nanoscale.

3. Study different types of nanophotonic crystal-based devices and systems.

Subject Code: NT45A5 Subject Name: INTRODUCTION TO OPTICS, LASERS AND PHOTONICS		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Provide deep understandings of light – matter interaction at nanoscale.	U
CO-02	Learn the Laser fundamentals and Laser systems	U, An,
CO-03	Learn the different types of nanophotonic crystal-based devices and systems.	U, An, A
CO-04	Learn the emerging area of nano photonics and the phenomena involved in such devices.	U, An, A
CO-05	Gain the design and scope of nano-photonics applications.	U, An, A

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: NATURE OF LIGHT 9

Nature of light – Dual nature – propagation – coherence – light sources , Quantized states of atoms, molecules - Electronic states of a molecule – Vibrational states of a molecule – Intermolecular effects - Various Types of Spectroscopy - Electronic Absorption Spectroscopy - Electronic Luminescence Spectroscopy -Vibrational Spectroscopy - Fluorescence Correlation Spectroscopy (FCS).

UNIT II: LASER **9**

Laser fundamentals, Laser systems- Ruby laser, He-Ne laser, dye laser, Argon ion laser, free electron laser, Nd YAG, CO2 laser, Diode laser, Nitrogen laser, excimer laser, Ti Sapphire laser, Fibre laser. Laser applications- Material processing, holography, LIDAR, Bio medical applications, laser fusion, laser cooling and Bose- Einstein condensates.

UNIT III: PHOTO DETECTORS AND DISPLAY DEVICES **9**

Photodiodes, Photo transistor, APD, PMT, CCD, PIN photo diodes, liquid crystal display, Photo voltaic cells. Optical modulators- acousto-optics, electro-optics and magneto-optics. Non linear optics.

UNIT IV: FIBRE OPTICS **9**

Classification of fibres- step index, graded index fibres, Numerical aperture, modes in optical fibre, single mode and multimode fibre, evanescent modes, losses in fibres, bending and coupling losses, dispersion in fibres. Fibre optic sensors- advantages of FOS, intensity modulated sensors, interferometric sensors, rotation sensors, Optical communication – advantages, modulation, time division and wave length multiplexing.

UNIT V: FOUNDATIONS OF PHOTONICS AND ITS APPLICATIONS **9**

Photons and Electrons - Similarities and differences, Light Interaction with Matter, Complex refractive index and dielectric constant, Dispersion in Materials. Confinement of Photons and Electrons, Co-operative effects for Photons and Electrons, TE/TM Mode, Optical fiber, filters, switching devices, Kerr effect devices; Super Lenses – Micro and Nano Lenses, Prisms and Meta- materials, Graphene photonics.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Introduction to Biophotonics - P. Prasad (Wiley, 2003)
2. MotoichiOhtsu, Kiyoshi Kobayashi, „Principles of Nanophotonics", CRC press, 2008
3. Bahaa E. A. Saleh, Malvin Carl Teich," Fundamentals of Photonics" 1991 John Wiley & Sons, Inc.
4. Paras Prasad, Nanophotonics, Wiley-Interscience, 2004.

NT45A6 LITHOGRAPHY AND MEMS 3 0 0 3

The course is aimed to:

1. Make them to understand the technology of MEMS and lithography.
2. Expose them about fabrication processes for development of MEMS/NEMS devices and systems

NT45A6 - Nanolithography and MEMS	
CO1	Understanding the basics of nanotechnology and lithography
CO2	Understanding the different types of Nanolithography techniques
CO3	Acquire the knowledge of mechanisms in MESM/NEMS and to obtain knowledge of Obtain the knowledge of MEMS fabrication
CO4	Understanding the principles and procedures of micro sensors actuators
CO5	To understand the nano materials types and application

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: LITHOGRAPHY TECHNIQUES 9

State-Of-The-Art (including principles, capabilities, limits, applications) EUV lithography – Phase- shifting photolithography – X-ray lithography, – Electron Beam Direct Writing System – Focused ion beam (FIB) lithography.

UNIT II: NANOLITHOGRAPHY TECHNIQUES 9

Neutral atomic beam lithography – Plasma-Aided Nanofabrication –Soft Lithography – Nanosphere Lithography – Nanoimprint – Dip-pen nanolithography – key consequences of adopted techniques.

UNIT III: INTRODUCTION TO MEMS AND MICROFABRICATION 9

Overview of MEMS / NEMS and various devices, Scaling geometry, Rigid Body Dynamics, Forces, Electron transfer, Fluid mechanics and Heat transfer. Microsystem fabrication process-Lithography, Dry and wet etching, Thin film deposition, PVD,CVD,LIGA, Micromolding, Electro-deposition

UNIT IV: PHYSICAL MICROSENSORS AND ACTUATORS 9

Classification of physical sensors, Integrated, Intelligent, or Smart sensors, Thermal sensors, Electrical Sensors, Mechanical Sensors, Chemical and Biosensors, Micro actuators: Electromagnetic and Thermal microactuation, Mechanical design of microactuators.

UNIT V: NANOMATERIALS FOR MEMS 9

Silicon – metals – polymers – complex nanomaterials for layer fabrication – smart probes and materials – Silicon Dioxide, Silicon Nitride, Piezoelectric materials, quantum dot based devices

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Marc J. Madou Fundamentals of Microfabrication: The Science of Miniaturization,Second Edition, 2002.
2. Edwin Oosterbroek, A. van den Berg, Lab-on-a-Chip: Miniaturized Systems for (Bio)Chemical Analysis and Synthesis, 2003
3. Tai-Ran Hsu, MEMS and microsystems: design and manufacture. McGraw-Hill, 2002 - Technology & Engineering
4. Guozhong Cao, Nanostructures &Nanomaterials Synthesis, Properties G; Z: Applications, World Scientific Publishing Private, Ltd., Singapore (2004).
5. W.R.Fahrner, Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques, Springer-Verlag Berlin, Germany (2006).
6. R. H. J. Hannink and A. J. Hill, Nanostructure control of materials, Woodhead Publishing Limited and CRC Press LLC, Cambridge, England (2006).
7. Zheng Cui, Nanofabrication, Principles, Capabilities and Limits, Springer Science business media, New York (2008)

NT45A7 SEMICONDUCTOR BASED ELECTRONIC DEVICES 3 0 0 3

Subject Code: NT45A7 Subject Name: Semiconductor based Electronics devices		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Understanding the semiconductor physics of the intrinsic, p and n Materials	R, U, A,An, S
CO-02	Understanding the characteristics of the p-n junction, the diode and some special function diodes and these diodes‟ application in electronic Circuits	R, U, A, An, E
CO-03	Understanding the structure, operation and characteristics of BJT	R, U, A, An E
CO-04	Demonstrate the switching and application of the amplification semiconductor devices (MOSFET).	R, U, A, An, E
CO-05	Understands the special semiconductor operation and its devices Characteristics	R, U, A, An

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO ELECTRONICS AND SEMICONDUCTORS9

Applications of Electronics- Modern Trends in Electronics Electronic Components- Sources of Electrical Power- Internal Impedance of a Source Concept of Voltage Source - Concept of Current Source- Semiconductor Materials- Structure of an Atom- Metals- Insulators and Semiconductors- Intrinsic Semiconductors- Extrinsic Semiconductors.

UNIT II: SEMICONDUCTOR DIODES 9

Diode fabrication, Device physics: Thermal equilibrium, Internal electro-static fields and potentials, Poisson‟s equation, continuity equations, drift-diffusion equations. I-V Characteristics: Forward bias, reverse bias, Diode equation. Capacitive effect: Junction and diffusion capacitance. DC, AC and transient analysis of Diodes.

UNIT III: BIPOLAR JUNCTION TRANSISTORS (BJTS) 9

Junction Transistor Structure - Working of a Transistor - Transistor Amplifying Action - Three Configurations - Transistor Characteristics - Comparison between the Three Configurations - Why is CE Configuration widely used in Amplifier Circuits - Basic CE Amplifier Circuit - Construction of Transistors- thermal Runaway and Heat Sink.

UNIT IV: MOSFET 9

MOS capacitor, MOSFET device fabrication, MOSFET Physics: I-V characteristics, Subthreshold region, Body effect, Capacitive effect, small and large signal model. MOSFET Short Channel effects: Punch through, DIBL, Hot electron effect, Velocity Saturation, Leakage current. MESFETs and MODFET analysis.

UNIT V: SPECIAL SEMICONDUCTOR DEVICES AND POWER DEVICES 9

Metal - semiconductor junction – Schottky Barrier Diode – Varactor Diode – Tunnel Diode – Gallium Arsenic Device – LASER diode – LDR, MESFET - UJT – SCR – DIAC – TRIAC DMOS – VMOS – LED – LCD

TOTAL: 45 HOURS

TEXT BOOKS:

1. Donald A Neaman, “Semiconductor Physics and Devices”, Third Edition, Tata Mc GrawHill
   Inc. 2007.

REFERENCE BOOKS:

2. Yang, “Fundamentals of Semiconductor devices”, McGraw Hill International Edition, 1978.
3. Robert Boylestad and Louis Nashelsky, “Electron Devices and Circuit Theory” Pearson
   Prentice Hall, 10th edition,July 2008.

NT45A8 ADVANCED NANOELECTRONIC BASED DEVICES AND CIRCUITS 3 0 0 3

Aim

To learn the characteristics of microelectronic sensing systems and semiconductors and to demonstrate the structure and operation of BJT and MOSFET

	NT45A8 Advanced Nanoelectronics Based Devices and Circuits
CO1	To know the characteristics of microelectronic sensing systems and semiconductors
CO2	To demonstrate the structure and operation of BJT and MOSFET
CO3	To analyze the performance of single electron devices
CO4	To study the Current Nanoelectronics Devices
CO5	Explore the fundamentals on QED, SED, Molecular electronics and spintronics.

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

- S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO MICROELECTRONICS, SEMICONDUCTOR PHYSICS AND IC TECHNOLOGY 9

The digital Inverter – Microelectronic sensing systems – Pure semiconductors – Generation, Recombination and thermal equilibrium – Doping – carrier transport – Silicon Integrated circuit technology.

UNIT II: PHYSICS OF BIPOLAR TRANSISTORS AND MOS TRANSISTORS 9

Bipolar transistors- Structure, operation – Bipolar Transistor models – Operation of bipolar transistor in saturation mode. Structure of MOSFET, operation of MOSFET – I/V characteristics – Channel length modulation – MOS transconductance – Velocity saturation – MOS device models – PMOS transistor – CMOS technology – Comparison of bipolar and MOS devices.

UNIT III: Single Electron Devices 9

Principle of operation- Single-Electron Effect, Coulomb Blockade Phenomenon; Theoretical Quantum Dot Transistor - Energy of Quantum Dot system, Single-Electron Quantum-Dot Transistor, Single transistors; Conductance Oscillation and Potential Fluctuation; Transport under Finite temperature and Finite Bias; Coulomb Blockade Devices.

UNIT IV: Current Nanoelectronic Devices 9

Quantum Effects in MOSFETs, Strained Silicon, Fully Depleted SOI-MOSFET, Double-Gate MOSFET, Multi-gate MOSFETs, FIN-FET, Electrically Induced Junctions for EJ-MOSFETs, Ballistic Transport, Conductance Quantization, Quantum Point Contact Devices.

UNIT V: Spintronics

Fundamentals of spintronics; Spintronic devices- spin diodes and spin transistors

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Fundamentals of Microelectronics, BehzadRazavi, Wiley edition, 2008
2. Microelectronics, an integrated approach by Roger T Howe, Charles G Sodini, Pearson education, 2004.
3. Microelectronics, Jacob Millman, Arvin Grabel, TMH.
4. John P. Uyemura, ―Introduction to VLSI Circuits and Systems‖, John Wiley & Sons 2002
5. Keshab K. Parthi, ‖ VLSI Digital Signal Processing Systems‖, John Wiley & Sons 2002
6. Konstantin K. Likharev, Single Electron Devices and their Applications, IEEE proceedings, vol. 87, no. 4, April 1999.p 606- 632.
7. Jan M. Rabaey and et al, ―Digital Integrated Circuits‖, Pearson Edn. Inc. 2003
8. Ziese and M. J. Thornton Spin Electronics, Springer-Verlag, 2001

NT45A9 RESEARCH METHODOLOGY AND IPR 3 0 0 3

Aim

- Identify an appropriate research problem in their interesting domain.
- Understand ethical issues
- Understand the Preparation of a research project thesis report
- Understand the law of patent and copyrights.
- Understand the Adequate knowledge on IPR

NT45A9 RESEARCH METHODOLOGY AND IPR	
CO1	Understand the research problem and research process.
CO2	Understand research ethics
CO3	Prepare a well-structured research paper and scientific presentations
CO4	Explore on various IPR components and process of filing.
CO5	Understand the adequate knowledge on patent and rights

- R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	M	M	S	M	M	S
CO-02	M	M	S	M	M	S
CO-03	M	M	S	M	M	S
CO-04	M	M	S	M	M	S
CO-05	M	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: RESEARCH DESIGN 9

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II: DATA COLLECTION AND SOURCES 9

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III: DATA ANALYSIS AND REPORTING 9

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV: INTELLECTUAL PROPERTY RIGHTS 9

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT V: PATENTS **9**

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL : 45 HOURS

REFERENCES :

1. Cooper Donald R, Schindler Pamela S and Sharma JK, Business Research Methods, Tata McGraw Hill Education, 11e (2012)
2. Intellectual property: patents, trademarks, copyrights, trade secrets. By Catherine J. Holland. Entrepreneur Press, 2007
3. Patent searching: tools & techniques. By David Hunt, et al. Wiley, 2007.
4. Professional Programme Intellectual Property Rights, Law and practice, The Institute of Company Secretaries of India, Statutory body under an Act of parliament, September 2013

NT45B1 NANOTOXICOLOGY 3 0 0 3

OBJECTIVES:

- To make students learn various concepts of toxicity, and its effects.
- To help them gain knowledge about the toxicity in Nanoscience, and their effects on Human.
- To enhance knowledge on the nanotoxicology - prevention and remedies.

OBJECTIVE:

To develop an understanding of the students to synthesize non-toxic, harmless nanomaterials that produce no hazard to the environment

COURSE OUTCOMES:

Subject Code: **NT45B1**	Subject Name: NANOTOXICOLOGY	
Course Outcome - COs		**Cognitive Skills**
CO-01	**Toxicology and toxicological chemistry:** Basic toxins produced, their chemical nature and their measured effects	U, A, An
CO-02	**Ecotoxicology:** Understanding the harmful effects of toxins in our ecosystem and their remedial measures	U, A, An
CO-03	**Nanomaterials and toxicity:** The mechanism of interaction of toxins to cells and mode of entry	U, A, An
CO-04	**Effect of nanomaterials on human health:** How the toxins do harm the human health and the different types of diseases that result from it.	U, A, An
CO-05	**Health hazards:** The methods of diagnosis of such diseases, mutagenesis and hypersensitivity reactions caused by them.	U, A, An

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	M	S	M	M	M
CO-02	S	M	S	M	M	M
CO-03	S	M	S	M	M	M
CO-04	S	M	S	M	M	M
CO-05	S	M	S	M	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO TOXICOLOGY 9

Concept of Toxicology-Types of toxicity based on route of entry, nature of the toxin Toxicodynamics–Dose vs Toxicity Relationships. Toxico kinetics – ADME, LADMET hypothesis. Genotoxicity and carcinogenicity – Mechanisms and Tests. Organ toxicity – Respiratory**,** dermal, hepato, neuro and nephro.

UNIT II: NANOTOXICOLOGY **9**

Characteristics of Nanoparticles that determine Potential Toxicity. Bio-distribution ofnanoparticles. Interation of Nanoparticles with Biomembrane and genes. Evaluation ofNanoparticle transfer using placental models. Nanomaterial toxicity – Pulmonary**,** dermal,hepato, neuro, ocular and nephro; Estimation of Nanoparticle Dose in Humans.In vitro toxicity studies of ultrafine diesel exhaust particles; Toxicity studies of carbon nanotubes

UNIT III: PROTOCOLS IN TOXICOLOGY STUDIES **9**

Methods for toxicity assessment – Cyto, Geno, hepato, neuro, nephrotoxicity. Assessment of toxicokinetics. Assessment of oxidative stress and antioxidant status.

UNIT IV: ANIMAL MODELS **9**

Types, species and strains of animals used in toxicity studies. Dosing profile for animalmodels. Studies on toxicology, pathology and metabolism in mouse and rat. Laws andRegulations Governing Animal Care and Use in Research.

UNIT V: RISK ASSESSMENT AND EXECUTION **9**

SRisk assessment of Nanoparticle exposure. Prevention and control of nanoparticles exposure. Regulation and recommendations.

TOTAL : 45 HOURS

REFERENCES:

1. John H. Duffus, Howard G. J. Worth, „Fundamental Toxicology", The Royal Society ofChemistry 2006.
2. Nancy A. Monteiro-Riviere, C. Lang Tran., „Nanotoxicology: Characterization, Dosing andHealth Effects",Informa Healthcare publishers, 2007.
3. Lucio G. Costa, Ernest Hodgson, David A. Lawrence, Donald J. Reed,WilliamF.Greenlee „Current Protocols in Toxicology", John Wiley & Sons, Inc. 2005.
4. Shayne C. Gad, „Animal models in toxicology", Taylor & Francis Group, LLC 2007.
5. P. Houdy, M. Lahmani, F. Marano, „Nanoethics and Nanotoxicology", Springer- Verlag BerlinHeidelberg 2011.
6. A Reference handbook of nanotoxicology by M.ZafarNyamadzi 2008.
7. Andreas Luch, „Molecular, Clinical and Environmental Toxicology Volume2: ClinicalToxicology", BirkhauserVerlag AG 2010.

NT45B2 NANOMATERIALS FOR ENERGY AND ENVIRONMENT 3 0 0

3 OBJECTIVES:

- To be aware of the challenges and demand for Energy
- To study about the nanomaterials used in Energy applications
- To enhance our knowledge on the role of nanomaterials in remediation applications and its impact on the environment.

COURSE OUTCOMES:

Subject Code: NT45B2 Subject Name: NANOMATERIALS FOR ENERGY AND ENVIRONMENT		
Course Outcome - COs		Cognitive Skill
CO-01	A proper understanding on sustainable energy-Energy conversion	U
CO-02	Students will gain knowledge on Renewable Energy Technology	U, An, A
CO-03	Candidates can understand clearly the Fuel Cell Technology	U, An, A
CO-04	Students can understand Microfluidic Systems	U, An, A
CO-05	Candidates will gain knowledge on Hydrogen storage methods - metal hydrides	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	M	S	M	M	S
CO-02	S	M	S	M	M	S
CO-03	S	M	S	M	M	S
CO-04	S	M	S	M	M	S
CO-05	S	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Sustainable energy - Materials for energy - Green house effect - CO_2 emission - Energy demand and challenges.

UNIT II: RENEWABLE ENERGY TECHNOLOGY 9

Development and implementation of renewable energy technologies. Nano, micro and mesoscale phenomena and devices. Energy conversion, transport and storage. High efficiency Photovoltaic solar cells. High performance thermoelectric systems - Integration and performance of DSSC- Quantum dots based solar cells.

UNIT III: NANOMATERIALS IN FUEL CELL AND STORAGE TECHNOLOGY 9

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems - thin film and microfabrication methods - design methodologies - micro-fuel cell power sources - Supercapacitors - Specific energy- charging/discharging - EIS analysis.

UNIT IV: HYDROGEN STORAGE AND PHOTOCATALYSIS 9

Hydrogen storage methods - metal hydrides - size effects - hydrogen storage capacity - hydrogen reaction kinetics - carbon-free cycle- gravimetric and volumetric storage capacities - hydriding/dehydriding kinetics - multiple catalytic effects - degradation of the dye - nanomaterials based photocatalyst design - kinetics of degradation.

UNIT V: ENVIRONMENTAL APPLICATIONS & IMPACTS OF NANOMATERIAL 9

Nanomaterials as adsorbents - Nanocomposite membrane systems for water remediation: Membrane fabrication; Membrane reactors & Active Membrane systems - Ecotoxicological impacts of nanomaterials - Lifecycle assessment of nanomaterials.

TOTAL : 45 PERIODS

REFERENCES:

2. J. Twidell and T. Weir, Renewable Energy Resources, Taylor & Francis Group, 2014 (4thEdition).
3. Ram B. Gupta, Hydrogen Fuel, CRC Press, Taylor and Francis Group, New York,2009
4. Gregor Hoogers, Fuel Cell Technology Hand Book, CRC Press, Taylor and Francis Group New York, 2003.
5. Hand Book of Fuel Cells: Fuel Cell Technology and Applications, Wolf Vielstich, Arnold Lamm, Hubert Andreas Gasteiger, Harumi Yokokawa, Wiley, London, 2003
6. Zhen Fang, Richard L Smith, Xinhua Qi, Production of Hydrogen from Renewable Resources, , Springer, London, 2016
7. Mark R. Wiesner, Jean-Yves Bottero, Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw Hill, New York, 2007.

NT45B3 INTERNET OF THINGS AND CLOUD COMPUTING 3 0 0 3

COURSE OBJECTIVES:

- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular

applications COURSE OUTCOMES:

Subject Code: NT45B3 Subject Name: INTERNET OF THINGS AND CLOUD COMPUTING		
Course Outcome - COs		Cognitive Skill
CO-01	Understand the various concept of the IoT and their technologies.	U
CO-02	Develop IoT application using different hardware platforms	U, An, A
CO-03	Implement the various IoT Protocols	U, An, A
CO-04	Understand the basic principles of cloud computing.	U, An, A
CO-05	Develop and deploy the IoT application into cloud environment	U, An, A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / **CO**	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F
CO-01	S	M	S	M	M	S
CO-02	S	M	S	M	M	S
CO-03	S	M	S	M	M	S
CO-04	S	M	S	M	M	S
CO-05	S	M	S	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I : FUNDAMENTALS OF IoT 9

Introduction to IoT – IoT definition – Characteristics – IoT Complete Architectural Stack – IoT enabling Technologies – IoT Challenges. Sensors and Hardware for IoT – Hardware Platforms Arduino, Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors.

UNIT II: PROTOCOLS FOR IoT 9

Infrastructure protocol (IPV4/V6/RPL), Identification (URIs), Transport (Wifi, Lifi, BLE), Discovery, Data Protocols, Device Management Protocols. – A Case Study with MQTT/CoAP usage-IoT privacy, security and vulnerability solutions.

UNIT III: CASE STUDIES/INDUSTRIAL APPLICATIONS 9

Case studies with architectural analysis: IoT applications – Smart City – Smart Water – Smart Agriculture – Smart Energy – Smart Healthcare – Smart Transportation – Smart Retail – Smart waste management.

UNIT IV: CLOUD COMPUTING INTRODUCTION 9

Introduction to Cloud Computing - Service Model – Deployment Model- Virtualization Concepts
– Cloud Platforms – Amazon AWS – Microsoft Azure – Google APIs.

UNIT V: IoT AND CLOUD 9

IoT and the Cloud - Role of Cloud Computing in IoT - AWS Components - S3 – Lambda - AWS IoT Core -Connecting a web application to AWS IoT using MQTT- AWS IoT Examples. Security Concerns, Risk Issues, and Legal Aspects of Cloud Computing- Cloud Data Security

TOTAL:45 HOURS

REFERENCES

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman, CRC Press, 2017
2. Adrian McEwen, Designing the Internet of Things, Wiley,2013.
3. EMC Education Services, “Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data”, Wiley publishers, 2015.
4. Simon Walkowiak, “Big Data Analytics with R” PackT Publishers, 2016
5. Bart Baesens, “Analytics in a Big Data World: The Essential Guide to Data Science and its Applications”, Wiley Publishers, 2015.