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 2021

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, KUMARACOIL

Regulation : 2021

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 centers.
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 Attributes-GA	
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 credits : 70

DEPARTMENT OF NANO TECHNOLOGY

M. Tech. NANO TECHNOLOGY

Regulation : 2021

SEMESTER I

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA3503	Applied Mathematics	3	1	0	4
2.	NT3501	Quantum Mechanics sin Nanostructures	3	0	0	3
3.	NT3502	Fundamentals of Nanoscience and Technology	3	0	0	3
4.	NT3503	Synthesis of Nanomaterials	3	0	0	3
5.	PEC1	Department Elective I	3	0	0	3
6.	PEC2	Department Elective II	3	0	0	3
PRACTICAL						
7.	NT3571	Synthesis and Preparation of Nanomaterials Laboratory	0	1	2	2
TOTAL			**18**	**2**	**2**	**21**

SEMESTER II

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	NT3504	Instrumental Methods of Analysis	3	0	0	3
2.	NT3505	Nanoelectronics and Sensors	3	0	0	3
3.	NT3506	Advanced Engineering Materials	3	1	0	4
4.	NT3507	Nanobiotechnology and Nanomedicine	3	0	0	3
5.	PEC3	Department Elective III	3	0	0	3
6.	PEC4	Department Elective IV	3	0	0	3
PRACTICAL						
7.	NT3572	Characterization of Nanomaterials Laboratory	0	1	2	2
TOTAL			**18**	**2**	**2**	**21**

SEMESTER III

SI. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	PEC	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.	NT35P1	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.	NT35P2	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.	NT35A1	Carbon Based Nanostructures	3	0	0	3
2.	NT35A2	Physics And Chemistry of Nanomaterials	3	0	0	3
3.	NT35A3	Drug Delivery Systems	3	0	0	3
4.	NT35A4	Polymer Science And Technology	3	0	0	3
5.	NT35A5	Biophysics	3	0	0	3
6.	NT35A6	Vacuum Science And Cryogenics	3	0	0	3
7.	NT35A7	Introduction to Optics, Lasers and Photonics	3	0	0	3
8.	NT35A8	Lithography and MEMS	3	0	0	3
9.	NT35A9	Semiconductor Based Electronic Devices	3	0	0	3
10.	NT35B1	Advanced Nanoelectronic Based Devices and Circuits	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.

SEMESTER I

MA3503 APPLIED MATHEMATICS 3 1 0 4

AIM:

To equip the students in the field of variational problems, application to queuing system and numerical techniques which provide necessary mathematical support and confidence to tackle real life problems.

OBJECTIVE:

To impart the basic knowledge about Matrices, Transforms, Conformal Mappings and Numerical problems so that those concepts could be adopted in their concerned branch.

COURSE OUTCOMES:

Subject Code: MA3503	**Subject Name: APPLIED 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

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 ADVANCED MATRIX THEORY 9

Generalised Eigen vectors– Jordan canonical form — Matrix norms – Singular value decomposition – Pseudo inverse – Least square approximations – QR decomposition.

UNIT II CALCULUS OF VARIATIONS 9

Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables —Isoperimetric Problems.

UNIT III SIMULATION 9

Discrete Event Simulation – Stochastic Simulation - Monte Carlo Simulation – Generation of Random Numbers using Congruent method – Applications to Queueing systems.

UNIT IV CONFORMAL MAPPING 9

Schwarz – Christoffel Transformation – Transformation of boundaries in parametric form – Physical applications – Application to fluid flow and heat flow.

UNIT V FIRST AND SECOND ORDER ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 9

Solution of first order differential equations -Single step Methods: Taylor's Series, Fourth order Runge-Kutta method. Finite difference solution of one dimensional heat equation: Bender Schmidt Method– One dimensional wave equation and two dimensional Poisson equations.

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

REFERENCES:

1. Bronson, R., "Matrix Operations", Schaum's Outline Series, McGraw–Hill, New York , 1989.
2. Spiegel, M.R.," Theory and Problems of complex variables with an introduction to conformal mapping and its applications. Schaum's outline series" McGraw-Hill Book Co,1964.
3. Gupta, A.S., "Calculus of Variations with Applications", Prentice-Hall of India, New Delhi, 1997.
4. Dr.Venkataraman, M.K., " Higher Mathematics for Engineering and Science", National Publishing Company, 1992.
5. Jain M.K., Iyengar. S.R.K and Jain. R.K, "Numerical method for scientific and Engineering Computations", New Age International (P) Ltd., Publishers, 2003.
6. Grewal B.S., "Higher Engineering Mathematics"- 40th Edition, Khanna Publishers, Delhi 2007.
7. Taha, H.A. "Operations Research: An Introduction", Ninth Edition, Pearson Education Edition, Asia, New Delhi, 2002.
8. K Sharma "Operations Research" Macmillan, 2003

NT3501 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 changes 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: **NT3501** 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 OPERATORS 9

Operators and linear operators – Inverse operators – Eigen values and Eigen functions – Operator formalism in quantum mechanics – Momentum operators – Hamiltonian operators – Orthogonal system - Hermitian and Unitary operators – Properties of Hermitian operators.

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 – Quantum Hall Effect – Nanosize Field Effect Transistors – High electron mobility transistor – 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.

NT3502 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: **NT3502** 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- surface defects- Effect on the Lattice Parameter – Moors law – Quantum Confinement – theory - Classification based on dimensionality – Quantum Dots, Wells and Wires - Opportunities at Nanoscale - Nano toxicology and Challenges.

UNIT – II NANOSCALE MATERIALS 9

Nanometer-Scale Metals:-Nanogold, Nanosilver, Nanocopper and Nanoiron - Nano Metal Oxides:- Aluminum Oxide, Titanium Dioxide, Zinc Oxide and Iron Oxides - Quantum Dots – 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

Properties at nanoscale - Electronics and Optoelectronics:- Quantum Confinement of Superlattices and Quantum Wells – Dielectric Constant of Nanoscale Silicon – Doping of a Nanoparticle – 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

Solar energy conversion and catalysis - Energy storage - Molecular electronics - Linear and Nonlinear optical and electro-optical properties - Displays and other devices -Nanomaterials for Data Storage -Photonics, Plasmonics - Chemical and biosensors -Nanomedicine and Health care.

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.

NT3503 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: **NT3503** 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 – Other undesirable Post-Condensation Effects – Nanoparticles' morphology.

UNIT –II SOLID STATE METHOD 9

High energy milling – Mechanical milling – Oven techniques – Melt and Mixing – ChemieDouce 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 - Carbon nanotubes and graphene - Core shell and hybrid nanocomposites.

UNIT –V APPLICATIONS OF NANOMATERIALS 9

Cosmetic applications of nanoparticles– nanocomposite materials – nanocoating – hard cutting tools using nanomaterials – fuel cells – batteries – displays.

TOTAL: 45 HOURS

REFERENCE BOOKS

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

NT3571 SYNTHESIS AND PREPARATION OF NANOMATERIALS LABORATORY

0 1 2 2

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 CuONanorods.

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

NT3504 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: **NT3504** 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 equipments 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 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).

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 of: X-ray Diffraction (XRD) – Dynamic Light Scattering (DLS) – Zeta Potential Analysis.

UNIT –IV MAGNETIC RESONANCE SPECTROSCOPY AND MASS SPECTROMETRY 9

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 ELECTROANALYTICAL METHODS 9

Electrochemical Cell – Oxidation\Reduction Reactions – Electrode Potentials – Reference Electrodes – The Nernst Equation – Redox Titration Curve – Junction Potential – Ion Selective Electrodes - pH Electrode – Ion Selective Field Effect Transistors – Potentiometric Titration – Linear Sweep Voltammetry – Cyclic Voltammetry – Stripping Voltammetry – Electroseparation with Controlled Electrode Potential.

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. Skoog, D. A., West, D. M., & Holler, F. J. (1992). Fundamentals of analytical chemistry. Fort Worth, Tex: Saunders College Pub.

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.

NT3505 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 semi conductors - 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-tunneling diodes, Field-effect transistors, Single-electron-transfer devices, Potential-effect transistors, Light-emitting diodes and lasers, Nano-electromechanical system devices.

UNIT –III SENSOR CHARACTERISTICS 9

Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies, calibration and standard, selectivity, sensitivity, reproducibility, detection limits, response time.

UNIT –IV PHYSICO-CHEMICAL SENSORS 9

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 –V 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

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.

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.

NT3506 ADVANCED ENGINEERING MATERIALS 3 0 1 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: **NT3506** 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 –IV COMPOSITES 9

Types of composite materials – the concept of load transfer – matrix materials - polymers, metals and ceramics - fibers - glass, boron, carbon, organic and metallic fibers-fiber packing arrangements - particle reinforced composites - fibre reinforced composites - structural composites – applications of composites – aerospace, automotive, medical, electrical field and others.

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.

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.

NT3507 NANOBIOTECHNOLOGY AND NANOMEDICINE 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: **NT3507** Subject Name: **NANOBIOTECHNOLOGY AND NANOMEDICINE**		
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 nanoparticlesand 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- 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 9

Nanomedicine: A Global Vision - The Nanotechnology Revolution: Realization of Asimov's Fiction - Nanomedicine: A New Era in Personalized Medicine - Cellular Structure- Various Types of Cells - Biochemical Makeup of Cells - Cellular Processes - Organization of Cells into Tissues - Types of Tissues and Their Functions - Various Organs and Organ Systems in the Body - Tumors and Cancers.

UNIT –II NANOCARRIERS 9

Nanocarriers: Delivering Payloads to Needed Sites - The Various Nanoformulations for Nanomedicine - Viruses as Nanocarriers - Polymeric Nanocarriers - Lipid-Based Nanocarriers - Dendrimers - Carbon Nanostructures - Inorganic Nanoparticles - PEBBLE - Nanoclinics - Nanoplexes - New-Generation Nanocarriers.

UNIT –III NANOPARTICLES FOR IMAGING AND DRUG DELIVERY 9

Enhancement for X-Ray and Tomography Imaging - Enhancements with MRI Imaging - Nanodots and Quantum Resonant Nanoparticles - Nanoparticles in the Enhancement of IR, Visible, and UV Imaging - Nanoparticles with Visible and UV Resonance for Cellular Probes - Nanoparticle Image Enhancement for Ultrasound and Optoacoustic Imaging - Combined Radiation and Photodynamic Therapy - Magnetic Nanoparticles for Targeting Cancer Cells - Nanotherapies for Insulin Delivery.

UNIT –IV NANOTECHNOLOGY IN RECONSTRUCTIVEINTERVENTION AND SURGERY 9

Endoscopy, Endoscopic Surgery, and Natural Orifice Translumenal Endoscopy (NOTES) - MEMS (Microelectromechanical Systems) for Endoscopic Imaging and Sensing Modalities - Access by Catheters: Nanotechnology Impacts - Techniques for Cerebrospinal Navigation and Endoscopy -

Telerobotics and Telesurgery - Robotics in Surgical Practice - Image-Guided Robotics in Radiation Oncology - Flexible Robotics: Robotic Activated Endoscopes and Catheters - Capsule Endoscopy.

UNIT –V NANOTECHNOLOGY IN TISSUE REPLACEMENT AND PROSTHETICS **9**

Fabrication of Nanofibrous Scaffolding. - Carbon Nanotubes in Tissue Scaffolding - Titanium Dioxide Nanoporous Films - Nanoparticle Materials for Wound Healing- Nanomaterials in Tissue Scaffolding for Cartilage and Bone - Nanoengineered Encapsulation and Implantation of Cells and Tissues - Neuroprosthetics - Brain–Machine Interface - Magnetic Neural Stimulation and Monitoring - Cognitive Prosthetics - Neuroprosthetics for the Ear - Vision Prosthetics

TOTAL: 45 HOURS

TEXT BOOKS:

1. Prasad, P. N. (2012). *Introduction to nanomedicine and nanobioengineering*. Hoboken, NJ: Wiley.
2. Tibbals, H. F. (2011). *Medical nanotechnology and nanomedicine*. Boca Raton, FL: CRC Press.

REFERENCE BOOKS:

1. Vogel, V. (2009). Nanomedicine. Weinheim, Germany: Wiley-VCH.
2. Jain, K. K. (2017). The handbook of nanomedicine. New York, NY: Humana Press.
3. Zhang, M., & Xi, N. (2009). Nanomedicine: A systems engineering approach. Singapore: Pan Stanford Pub.

NT3572 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 various nanocharacterization 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 – Spectrofluorimeter
11. Porosity – Porosimeter
12. Mechanical property – Universal Testing Machine
13. Morphology – SEM/AFM/TEM
14. Conductivity – STM

ELECTIVES:

NT35A1 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: NT35A1 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 CARBON 9

Carbon - an element – 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) – graphene & graphene oxide functionalization.

UNIT – V APPLICATIONS 9

Electrode material for super capacitor – Energy storage (Graphite) – Hydrogen Storage (CNT, Aerogels) - thermal protection systems (C-C composites) – fuel cell – Structural Stability (carbon fiber composite) – diamond like film (Abrasive) – Sensors and Biosensors (Graphene & Graphene Oxides)- graphene intercalated compounds.

TOTAL: 45 HOURS

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).

NT35A2 PHYSICS AND CHEMISTRY OF NANOMATERIALS 3 0 0 3

PREREQUISITE: Science of Nanomaterials.

AIM: To study the physical phenomena and chemical kinetics involved in the nanostructured materials.

OBJECTIVE: To study the surface physics and chemistry of nanostructured materials, chemical properties inherent to the nanostructured materials, electronic structure of nanomaterials, growth of CNTs.

COURSE OUTCOMES:

Subject Code: **NT35A2** Subject Name: **PHYSICS AND CHEMISTRY OF NANOMATERIALS**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Understand and describe Physical and chemical aspects of Nano materials	R, U
CO-02	Understand and describe diffusion at nanoscale	U, An, A
CO-03	Understand and describe surface defects in nanostructures	U, An, A
CO-04	Understand and describe different classification of nanostructures	U, An, A
CO-05	Understand and describe growth of Nano systems	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 **9**

Melting point and phase transition processes-quantum-size-effect (QSE)-Size-induced metal insulator- transition (SIMIT)- Nano-scale magnets, transparent magnetic materials, and ultrahigh-density magnetic recording materials-chemical physics of atomic and molecular clusters.

UNIT –II **9**

Surface energy – chemical potential as a function of surface curvature-Electrostatic stabilization-surface charge density-electric potential at the proximity of solid surface - Vander Waals attraction potential.

UNIT –III **9**

Photochemistry- Photoconductivity- Electrochemistry of Nanomaterials-Diffusion in Nanomaterials-Nanoscale-Heat Transfer-Catalysis by Gold Nanoparticles - Transport in Semiconductor Nanostructures - Nanodeposition of Soft Materials- Nanocatalysis.

UNIT –IV **9**

Electronic Structure of Nanoparticles - Kinetics in Nanostructured Materials- Zero dimensional, one-dimensional and two dimensional nanostructures- clusters of metals and semiconductors, nanowires, nanorods and nanocomposites - artificial atomic clusters-size dependent properties-size dependent absorption spectra-phonons in nanostructures.

UNIT –V **9**

Single walled carbon nanotube - inorganic nanotube - Nanoparticles through homogeneous nucleation-Growth controlled by diffusion-growth controlled by surface process-influences of reduction reagents-solid state phase segregation-kinetically confined synthesis of nanoparticles-template based synthesis-nano structured polymers-conducting polymers nanocages - pillared clays-micelles.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Physics and Chemistry of Nanostructured Materials, Yang.S, Shen. P. Taylor & Francis, 2000.
2. Nanomaterials: Synthesis, Properties and Applications, Edelstein. A. S., Cammarata, R.C,
3. Institute of Physics Pub., 1998.
4. Surface Science: Foundations of Catalysis and Nanoscience, Kolasinski, K.W., Wiley, 2002.
5. The Physics and Chemistry of Materials, Joel I.Gersten, Wiley, 2001.
6. Nanochemistry, A chemical approach to Nanomaterials, Ozin G.A., Arsenault A.C., Royal Society of Chemistry, 2005.

NT35A3 DRUG DELIVERY SYSTEMS 3 0 0 3

AIM: To study the concept behind the various types of drug delivery systems

OBJECTIVE: The objective of the course is to understand the phenomenon taking place inside the body when a drug is administered via the various drug delivery systems.

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: **NT35A3** 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 **9**

Principles of drug delivery systems – Pharmacokinetics & Pharmacodynamics(qualitative) - ADME hypothesis – routes of administration - advantages and limitations – modes of drug delivery – controlled drug delivery – microneedles, micropumps and valves – sustained release system – targeted drug delivery – barriers for drug targeting – passive and active targeting – antibody–based targeting.

UNIT –II **9**

Diffusion & drug dispersion – Fick's first & second laws – Cases: With no solute elimination or generation, With solute binding & elimination – Diffusion in biological systems – Measurement of diffusion coefficients – Diffusion in water, polymer solutions & gels, in extracellular space, with binding in tissues, within cells.

UNIT –III **9**

Drug permeation through biological barriers – Mobility of lipids & proteins in membrane – Permeation through lipid membranes, porous membranes, through cell layers – Enhanced permeation by membrane proteins – Drug transport through fluid motion – Blood movement in the circulatory system – Interstitial fluid movement – Fluid movement in lymphatic circulation, brain.

UNIT –IV **9**

Pharmacokinetics of drug distribution – Compartment models – Physiological models –Mixing in tissues & organs – Drug delivery – Drug modification – Agent solubility – stability – enhancement of stability – Regulating agent permeability.

UNIT –V **9**

Controlled drug–delivery systems – Reservoir & transdermal delivery systems – Matrix delivery systems – Hydrogel delivery systems – Degradable delivery systems – Particulate delivery systems – Responsive delivery systems.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Drug Delivery: Engineering Principles for Drug Therapy, W. M. Saltzman, Oxford University Press, 2001.
2. Drug Delivery and Targeting, A.M.Hillery, CRC Press, 2002
3. Nanoparticulate Drug Delivery Systems Deepak Thassu , Michel Deleers (Editor), Yashwant Pathak (Editor) ISBN–10: 0849390737 ISBN–13: 9780849390739

NT35A4 POLYMER SCIENCE AND TECHNOLOGY 3 0 0 3

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 SYNTHESIS OF POLYMERS 9

Introduction - Raw materials – Polymerization techniques - Condensation and solution polymerization - RAFT and ATRP polymerization - reactors for polymerization – Specific Technology of polymerization – copolymerization techniques.

UNIT – II CLASSIFICATION OF POLYMERS 9

Introduction – Classification of natural, modified and synthetic polymers - water soluble polymers- thermoplastic resins - thermosetting resins - rubbers and fibers.

UNIT – III PROPERTIES OF POLYMERS 9

Mechanical: Deformation of plastic materials- classification of plastic materials based on their stress – strain relationship. Thermal: melting and crystallization, thermal conductivity – thermal expansion and contraction - factors affecting thermal expansion. Electronics: Electrical properties at low stress and high stress, electrically conductive plastics – electrical applications of plastics. Rheology: Melt flow properties, factors affecting shear flow and elongational flow – MFI, melt elasticity.

UNIT – IV BIODEGRADABLE POLYMERS 9

Principles of biodegradation - modes of biological degradation – microbial degradation of synthetic polymers - Disposal of solid municipal waste by biodegradation.

UNIT – V ENGINEERING APPLICATIONS 9

Electrical and electronic applications – High temperature applications - Polymer blends and alloys - liquid crystalline polymers - Polymers in lithography – polymer complexes for water treatment - Polymer for biomedical applications.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. F.W. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.
2. J.A. Biesenberger and H.Sebastian, Principles of Polymerization Engineering, Wiley Interscience Publication, New York, 2007.
3. J.A. Brydson, Plastics Materials, Newness - Elsevier, Seventh Edn, London, 2014.
4. R.L. Davidson and S. Marshall, Water Soluble Resins, Van-Nostrand Reinhold, New York, 1988.
5. H.F. Mark (Ed), Encyclopedia of Polymer Science and Engineering, Wiley – Interscience, New York, 1991.
6. L.L. Chapoy (Ed), Recent Advances in Liquid Crystalline Polymers, Chapman and Hall, London, 1985.

NT35A5 BIOPHYSICS 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: **NT35A5** Subject Name: NANOTECHNOLOGY IN HEALTH CARE		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Comprehend the nanoparticles-based gene therapy, nanoprobing and profiling techniquesand their application	R, U
CO-02	Understand the use of metal nanoparticles and antibodies in diagnosis of biomarkers withhigh sensitivity	U, An, A
CO-03	Be aware of the principle and uses of cantilever sensors and imaging of plaques and tumors	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 inorganicnanoparticles	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 STUDIES ON BIOMOLECULES 9

Structures of water, amino acids, peptides and proteins; chemistry of DNA, RNA, proteins, lipids and carbohydrates; elementary enzymology and molecular biology; genetic code – transfer of genetic information – physics of biological membranes – types of transport thru membranes – Extracellular matrix — carbohydrates – lipids.

UNIT – II BIOENERGETICS 9

Chemical binding – Pauli Exclusion Principle – Ionization energy – electron affinity – electronegativity – forces and bonds – rates of reactions – viscosity – thermal conduction-Thermodynamics and biological systems – bioenergetics – principles of kinetics of molecules – diffusion – osmosis – filtration – dialysis – absorption – hydrotropy – precipitation –viscosity – colloids – Gibb's Donnan equilibrium.

UNIT – III BIOMOLECULAR CHARACTERIZATION 9

pH meter – buffers in biological systems – centrifugation – centrifuges – chromatography(Qualitative) – electrophoresis – electron microscopy(qualitative) – X-Ray crystallography – Spectroscopy(Qualitative) – Optical Rotatory Dispersion – Circular Dichroism – Mass spectrometry – LASER techniques- sequencing.

UNIT – IV BIOMECHANICS 9

Biomechanics – striated muscles – mechanical properties of muscles – biomechanics of cardiovascular system – Neurobiophysics – nervous system – membrane potentials – sensory mechanism-eye – hearing – signal transduction – molecular modelling - generating the model – building nucleic acid structures and protein structures – optimising the model – Origin and evolution of life- Atomic orbital models.

UNIT – V MICROSCOPY 9

Light microscope, Resolving Power, Phase contrast microscope, Detection of small differences in refractive indices, Interference microscopy, Dark field microscopy, Light scattering at cell boundaries, Polarization microscopy, Fluorescence microscopy, Cytophotometry methods, Flowcytometry& cell sorting- Autoradiography.

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Carson, R. Silent Spring, Fawcett World Library, New York, 1967.
2. Török, P. (Ed), Kao, F. (Ed) Optical Imaging and Microscopy, (2007) Springer publications
3. Dawkins, R. The Blind Watchmaker, Longman Scientific & Technical, England, 1986.
4. R. Gadagkar, Survival Strategies – Cooperation and Conflict in Animal Societies, Harvard University Press and Universities Press, Cambridge, Massachusetts, USA and Hyderabad, India, 1997, 1998.
5. D. Sadava, D. M. Hillis, H. Craig Heller, M. Berenbaum, Life, the science of biology, W. H. Freeman, 9th edition, 2009.
6. J. M. Berg, J. L. Tymoczko, L. Styrer, Biochemistry, W. H. Freeman & Co., 6 th edition, 2006.
7. R. Y. Stanier, E. A. Adelberg, J. L. Ingraham, General Microbiology, MacMillan Press, 5 th edition, 2007.
8. M.W. Strickberger, Genetics, Prentice-Hall, India, 3 rd edition, 2008.

NT35A6 VACUUM SCIENCE AND CRYOGENICS 3 0 0 3

OBJECTIVE: The objective of the course is to provide a technological background of the basic knowledge of production of Vacuum and Low Temperatures.

COURSE OUTCOMES:

Subject Code: **NT35A6** Subject Name: **VACUUM SCIENCE AND CRYOGENICS**	
Course Outcome – Cos	**Cognitive Skill**

CO-01	To outline and define the concepts of vacuum science.	R, U
CO-02	To illustrate and show different techniques for vacuum science and engineering.	U, An, A
CO-03	To establish foundations of cryogenics.	U, An, A
CO-04	To appraise and illustrate the applications and handling of cryogens and technology.	U, An, A
CO-05	To analyze and evaluate the use of vacuum systems and cryogenic technologies in advanced scientific research and industrial 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 VACUUM PHYSICS 9

Basic terms and concepts in vacuum technology - Atmospheric air – Gas laws and models: Continuum theory – Kinetic gas theory – The pressure ranges in vacuum technology and their characterization – Types of flow and conductance: Types of flow – Calculating conductance values – Conductance for piping and opening.

UNIT –II VACUUM GENERATION 9

Vacuum pumps: A survey: Diaphragm pumps – Liquid ring pumps – Oil sealed rotary displacement pumps –Turbomolecular pumps – Diffusion pump – Sorption pumps: Adsorption pumps – Sublimation pumps – Sputter-ion pumps – Cryopumps – Pumping of gases (dry processes) Pumping of gases and vapors (wet processes) – Evacuation of a vacuum chamber.

UNIT –III VACUUM MEASUREMENT, MONITORING, CONTROL AND REGULATION 9

Fundamentals of low pressure measurement – Vacuum gauges: Bourdon vacuum gauges –Capsule vacuum gauges – DIAVAC diaphragm vacuum gauge – Precision diaphragm vacuum gauges – Capacitance diaphragm gauges – U-tube vacuum gauges – Compression vacuum gauges (McLeod) – Spinning rotor gauge – Thermal conductivity vacuum gauges – Ionization vacuum gauges – Cold-cathode ionization vacuum gauges – Hot-cathode ionization vacuum gauges – Fundamentals of pressure monitoring and control – Pressure regulation and control in rough, medium, high and ultrahigh vacuum systems.

UNIT –IV CRYOGENIC LIQUEFACTION 9

Thermodynamically Ideal System – Liquefaction of gases (Nitrogen, Oxygen, Hydrogen, Helium): Simple Linde Hampson System – Precooled Linde Hampson System – Linde Dual Pressure System – Claude System – Kapitza System – Heylandt System – Collins System.

UNIT –V MEASUREMENT AND STORAGE OF CRYOGENIC LIQUIDS 9

Temperature: Thermocouples – Metallic Resistance Thermometer – Semiconductor Resistance Thermometer – Constant Volume Gas Thermometer – Vapour-Pressure Thermometer – Magnetic Thermometer – Pressure: Hydrostatic Gauge – McLeod Gauge – Thermal Conductivity Gauge – Ionization Gauge - Storage Vessel: Thermal Shields and Insulation – Transport and transfer of Cryogenic fluids.

TOTAL: 45 HOURS

TEXT BOOKS:

1. Walter Umrath., (1998). Fundamentals of Vacuum Technology. Book on Demand.
2. MamataMukhopadhyay., (2014). Fundamentals of cryogenic engineering. Delhi: PHI Learning Private Limited.

REFERENCE BOOKS:

1. Chambers, A., Fitch, R. K., & Halliday, B. S. (2005). Basic vacuum technology. Bristol: Institute of Physics Pub.
2. John F. O'Hanlon. (2005). A User's Guide to Vacuum Technology. Wiley.
3. Flynn, T. M. (2005). Cryogenic engineering. New York: Marcel Dekker.

NT35A7 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: NT35A7 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 OPTICAL IMAGING

An Overview of Optical Imaging - Transmission Microscopy - Simple Microscope - Compound Microscope - Phase Contrast Microscopy - Dark-Field Microscopy - Fluorescence Microscopy - Confocal Microscopy - Near-Field Optical Microscopy - Fluorescence Resonance Energy Transfer (FRET) - Nonlinear Optical Imaging - Miniaturized Microscopes

TOTAL: 45 HOURS

REFERENCE BOOKS:

1. Introduction to Biophotonics - P. Prasad (Wiley, 2003)
2. Motoichi Ohtsu, Kiyoshi Kobayashi, ‘Principles of Nanophotonics’, CRC press, 2008

3. Bahaa E. A. Saleh, Malvin Carl Teich,' Fundamentals of Photonics' 1991 John Wiley & Sons, Inc.

NT35A8 NANOLITHOGRAPHY 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 MEMS MICROFABRICATION AND MICROMACHINING 9

Historical Background: Silicon Pressure sensors, Micromachining, Microfabrication, Integrated Circuit Processes, Bulk Micromachining: Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA).

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, Microactuators : 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. MadouFundamentals 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 manufactureMcGraw-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).

NT35A9 SEMICONDUCTOR BASED ELECTRONIC DEVICES

3 0 0 3

Subject Code: NT35A9 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 amplification application of the semiconductor devices (MOSFET)	R, U, A,An,E
CO-05	Understands the special semiconductor devices operation and its 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 SEMICONDUCTORS 9

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

PN-Junction - Junction Theory - V-I Characteristics of a PN-Junction Diode - The Ideal Diode - Static and Dynamic Resistance of a Diode - Use of Diodes in Rectifiers - How Effectively a Rectifier Converts AC into DC - How to get a Better DC - Types 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 FIELD EFFECT TRANSISTORS (FETS) 9

Junction Field-Effect Transistor (JFET) Metal-Oxide Semiconductor FET (MOSFET) Depletion-Type MOSFET (DE MOSFET) - Enhancement-Type MOSFET (EN MOSFET) - Complementary MOS (CMOS) - Comparison of JFET, MOSFET and BJT.

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.

NT35B1 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

	NT35B1 Advanced Nanoelectronic 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 Nanoelectronic 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 –V ADVANCED TECHNIQUES IN CMOS CIRCUITS DESIGN 9

Advanced techniques in CMOS Logic Circuits-Mirror circuits, Pseudo nMOS, Tri-state circuits, Clocked CMOS, Dynamic CMOS Logic circuits, Dual Rail Logic Networks. Arithmetic Circuits in CMOS VLSI-Bit Adder Circuits, Ripple Carry Adder, Carry Look Ahead Adders, Other High speed adders- Multiplexer based fast binary adders, Multipliers.

UNIT –III CMOS INVERTERS AND LOW POWER DESIGN 9

CMOS Inverter - Static Behaviour, Performance of CMOS Inverter -Dynamic Behaviour, Power Energy and Energy Delay, CMOS Circuit and Logic Design-CMOS Logic structures. Low power design- Scaling Versus Power consumption, Power reduction techniques.

UNIT –IV VLSI DESIGN 9

VLSI physical design automation and Fabrication VLSI Design cycle-New trends in VLSI design-Physical design cycle- Design style- Introduction to fabrication process, design rules- layout of basic devices, VLSI automation.

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. Neil H. E. Weste, Kamran Eshranghian, ―Principles of CMOS Design‖, Pearson Education
7. Asia 2000
8. Jan M. Rabaey and et al, ―Digital Integrated Circuits‖, Pearson Edn. Inc. 2003
9. NaveedShervani, ―Algorithms for VLSI physical design Automation‖, Kluwer AcademicPublisher, Second edition

GE35A1 BUSINESS ANALYTICS 3 0 0 3

AIM:

To understand the basic concepts of Business Analytics and other operational techniques.

OBJECTIVES:

- To make students understandable about the Regression Analysis, Business analytics, forecasting and decision analysis.

COURSE OUTCOMES:

Subject Code: **GE35A1** Subject Name: **BUSINESS ANALYTICS**

	Course Outcome – Cos	**Cognitive Skill**
CO-01	Ability to understand the concepts of Business Analytics.	R, U
CO-02	Can understand the factors of Trendiness and Regression analysis.	U, An, A
CO-03	Students can understand about organization structures of business analytics.	U, An, A
CO-04	One can understand the concepts of Forecasting Techniques.	U, An, A
CO-05	Can understand the Decision analysis.	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- BUSINESS ANALYTICS: 9

Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modeling, sampling and estimation methods overview.

UNIT II-TRENDINESS AND REGRESSION ANALYSIS: 9

Modeling Relationships and Trends in Data, simple Linear Regression.

Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

UNIT III-ORGANIZATION STRUCTURES OF BUSINESS ANALYTICS: 9

Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.

Descriptive Analytics, predictive analytics, predicative Modeling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modeling, nonlinear Optimization.

UNIT IV-FORECASTING TECHNIQUES: 9

Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT V-DECISION ANALYSIS: 9

Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, the Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data

Recovery, Data Storytelling and Data journalism.

TOTAL: 45 HOURS

REFERENCES

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G.Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

GE35A2 INDUSTRIAL SAFETY 3 0 0 3

AIM:

To understand the basic Industrial Safety and Fault diagnosis.

OBJECTIVES:

- To make students understandable about the Industrial safety, Maintenance and fault tracing.

COURSE OUTCOMES:

Subject Code: **GE35A2** Subject Name: **INDUSTRIAL SAFETY**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Ability to understand the concepts of Industrial Safety.	R, U
CO-02	Can understand the fundamentals of Maintenance Engineering.	U, An, A
CO-03	Students can understand the ways to prevent from wear and corrosion.	U, An, A
CO-04	One can understand the concepts of fault tracing.	U, An, A
CO-05	Can understand the functions of periodic and preventive maintenance.	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- INDUSTRIAL SAFETY: 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II- FUNDAMENTALS OF MAINTENANCE ENGINEERING: 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III- WEAR AND CORROSION AND THEIR PREVENTION: 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV- FAULT TRACING: 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V- PERIODIC AND PREVENTIVE MAINTENANCE: 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

TOTAL: 45 HOURS

REFERENCES

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

GE35A3 OPERATIONS RESEARCH 3 0 0 3

AIM:

To understand the concepts behind Operations Research.

OBJECTIVES:

- To make students understandable about the optimization techniques

COURSE OUTCOMES:

Subject Code: **GE35A3** Subject Name: **OPERATIONS RESEARCH**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Ability to understand the concepts of Optimization Techniques.	R, U
CO-02	Can understand the fundamentals of LPP formulation.	U, An, A
CO-03	Students can understand the Non-Linear Programming.	U, An, A
CO-04	One can understand the concepts Scheduling and Sequencing.	U, An, A
CO-05	Can understand the functions of Competitive models	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- OPTIMIZATION TECHNIQUES: 9

Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

UNIT II- LPP FORMULATION: 9

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

UNIT III- NONLINEAR PROGRAMMING: 9

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

UNIT IV- SCHEDULING AND SEQUENCING: 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

UNIT V- COMPETITIVE MODELS: **9**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

TOTAL: 45 HOURS

REFERENCES

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

GE35A4 COST MANAGEMENT OF ENGINEERING PROJECTS 3 0 0 3

AIM:

To understand the concepts of Cost management of Engineering Projects.

OBJECTIVES:

- To make students understandable about the cost concepts in decision making and profit planning.

COURSE OUTCOMES:

Subject Code: **GE35A4** Subject Name: **COST MANAGEMENT OF ENGINEERING PROJECTS**		
Course Outcome - COs		**Cognitive Skill**
CO-01	Ability to understand the strategic cost management.	R, U
CO-02	Can understand the fundamentals of cost concepts in decision making.	U, An, A
CO-03	Students can understand the process involved in project execution.	U, An, A
CO-04	One can understand the concepts of cost behavior and profit planning.	U, An, A
CO-05	Can understand the functions of quantitative techniques. .	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 - STRATEGIC COST MANAGEMENT: 9

Introduction and Overview of the Strategic Cost Management Process.

UNIT II- COST CONCEPTS IN DECISION MAKING: 9

Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

UNIT III- PROJECT: 9

Meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

UNIT IV- COST BEHAVIOR AND PROFIT PLANNING: 9

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

UNIT V- QUANTITATIVE TECHNIQUES: 9

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

TOTAL: 45 HOURS

REFERENCES

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler Publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

GE35A5 COMPOSITE MATERIALS 3 0 0 3

AIM:

To understand the characterization and properties of composite materials.

OBJECTIVES:

- To make students understandable about the material characteristics, processing and classifications of composite materials.

COURSE OUTCOMES:

Subject Code: **GE35A5** Subject Name: **COMPOSITE MATERIALS**		
Course Outcome – Cos		**Cognitive Skill**
CO-01	Ability to understand the functional requirements of composite materials.	R, U
CO-02	Can understand the properties and applications of reinforcements.	U, An, A
CO-03	Students can understand the process involved in metal matrix composite fabrication.	U, An, A
CO-04	One can understand the concepts of polymer matrix composites fabrication.	U, An, A
CO-05	Can understand the physical characteristics of composite 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: 9

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II- REINFORCEMENTS: 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT III- MANUFACTURING OF METAL MATRIX COMPOSITES: 9

Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT IV-MANUFACTURING OF POLYMER MATRIX COMPOSITES: 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT V- STRENGTH: 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 HOURS

TEXT BOOKS

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

REFERENCES

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

GE35A6 WASTE TO ENERGY 3 0 0 3

AIM:

To understand the basic properties of Bio Materials and its process

OBJECTIVES:

- To make students understandable about the gasification process, bio materials and its design considerations.

OUTCOMES:

- Ability to understand the process of obtaining Energy from waste substances.
- Can understand manufacturing of pyrolytic oils and gases, yields and applications.
- Students can understand kinetic consideration in gasifier operation.

- One can understand the Design, construction and operation of Bio Mass chamber.
- Can understand the basic Properties of biogas

UNIT I- INTRODUCTION TO ENERGY FROM WASTE: 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

UNIT II- BIOMASS PYROLYSIS: 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods -Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III- BIOMASS GASIFICATION: 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers –Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV- BIOMASS COMBUSTION: 9

Biomass stoves – Improved chullahs, types, some exotic designs, fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT V- BIOGAS: 9

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 HOURS

REFERENCES

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.