VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examination and Syllabus
B. E. NANO TECHNOLOGY (NT)
III-VIII SEMESTER
(Effective from Academic year 2018-19)

B. E. Common to all Programmes
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

TRANSFORM CALCULUS, FOURIER SERIES AND NUMERICAL TECHNIQUES

Course Code	**18MAT31**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	**3**	Exam Hours	03

Course Learning Objectives:

- To have an insight into Fourier series, Fourier transforms, Laplace transforms, Difference equations and Z-transforms.
- To develop the proficiency in variational calculus and solving ODE's arising in engineering applications, using numerical methods.

Module-1

Laplace Transform: Definition and Laplace transforms of elementary functions (statements only). Laplace transforms of Periodic functions (statement only) and unit-step function – problems.
Inverse Laplace Transform: Definition and problems, Convolution theorem to find the inverse Laplace transforms (without Proof) and problems. Solution of linear differential equations using Laplace transforms.

Module-2

Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions period 2π and arbitrary period. Half range Fourier series. Practical harmonic analysis.

Module-3

Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Problems.
Difference Equations and Z-Transforms: Difference equations, basic definition, z-transform-definition, Standard z-transforms, Damping and shifting rules, initial value and final value theorems (without proof) and problems, Inverse z-transform and applications to solve difference equations.

Module-4

Numerical Solutions of Ordinary Differential Equations(ODE's):
Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Runge - Kutta method of fourth order, Milne's and Adam-Bashforth predictor and corrector method (No derivations of formulae)-Problems.

Module-5

Numerical Solution of Second Order ODE's: Runge -Kutta method and Milne's predictor and corrector method. (No derivations of formulae).
Calculus of Variations: Variation of function and functional, variational problems, Euler's equation, Geodesics, hanging chain, problems.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Use Laplace transform and inverse Laplace transform in solving differential/ integral equation arising in network analysis, control systems and other fields of engineering.
- CO2: Demonstrate Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- CO3: Make use of Fourier transform and Z-transform to illustrate discrete/continuous function arising in wave and heat propagation, signals and systems.
- CO4: Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.
- CO5:Determine theexternals of functionals using calculus of variations and solve problems arising in dynamics of rigid bodies and vibrational analysis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2016
2	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition, 2016
Reference Books				
1	Advanced Engineering Mathematics	C.Ray Wylie, Louis C.Barrett	McGraw-Hill Book Co	6th Edition, 1995
2	Introductory Methods of Numerical Analysis	S.S.Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B.V.Ramana	McGraw-Hill	11th Edition,2010
4	A Textbook of Engineering Mathematics	N.P.Bali and Manish Goyal	Laxmi Publications	6th Edition, 2014
5	Advanced Engineering Mathematics	Chandrika Prasad and Reena Garg	Khanna Publishing,	2018

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

FOUNDATIONS OF NANOSCALE SCIENCE AND TECHNOLOGY

Course Code	**18NT32**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:
In this course students will learn about the basics of nanoscale science, types of materials, and their engineering applications and hazards.

Module-1

INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY
History, background and interdisciplinary nature of nanoscience and nanotechnology, challenges of Rechard Feynman, scientific revolutions, nanosized effects surface to volume ratio, examples of surface to volume ratio, atomic structure, Bohr atomic model, molecules and phases, introduction to classical physics and quantum mechanics, importance of nanoscale materials and their devices.

Module-2

CLASSIFICATION OF NANOSTRUCTURES
Zero dimensional, one-dimensional and two dimensional nanostructure materials - classification of solids: conductor, semiconductors, insulator, types of semiconductor, doping, diodes, current flow in semiconductors, ceramics and nanocomposites, quantum size effect(QSE) in 1D, 2D, 3D nanomaterials, quantum dots, nanowires, nanotubes, nanosheets, top down and bottom up approach.

Module-3

BIOMIMETICS AND BIOMATERIALS
Biomimetics: Biomimetics: lessons from nature – Introduction, Industrial significance, Lessons from nature and applications, overview of various objects from nature and their selected functions, Lotus effect, Velcro effect, biologically inspired mechanisms, Biologically inspired structures and tools, biological materials.
Biomaterials: Introduction, Classification of Biomaterials, Biomaterials as implant in human body, characterization of biomaterials.

Module-4

INTRODUCTION TO NANOMATERIALS AND DEVICES:
Types of nanomaterials: Metal nanoparticles eg Au, Ag, Cu, Pt and their application as FETs. Metal oxide nanoparticles TiO_2, ZnO, SnO_2 and their application in solar cells, MEMS based gas sensors, Semiconducting Cadmium and Selenide quantum dots bio imaging, Carbon based nanomaterials and their applications in FETs, MOSFETS, sensors and actuators, Silicon based nanostructures and their application in single electron electronics used as tips for AFM and Field emission microscopy, magnetic and ceramics nanomaterials and their application.

Module-5

INTRODUCTION TO NANOTOXICOLOGY:
Nanomaterials pollution – Nanomaterials in Environment - Toxicology of Airborne – Effect of Nanomaterials in the environment. Safety and pollution Control techniques-handling, storage, packaging, transportation and disposal.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Describe fundamentals of nanoscience and nanotechnology;
- CO2: Classify nano-structures;
- CO3: Develop smart materials;
- CO4: Analyse biomaterials;
- CO5: Explain nanotoxicology.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanophysics and Nanotechnology - An Introduction to Modern Concepts in Nanoscience	Edward L. Wolf	John Wiley & Sons	Second Edition, 2006
2	Foundations of Nanoscale Science and Technology	Shareefraza J. Ukkund, Prasad Puthiyillam	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-958649-3	First Edition, 2018
Reference Books				
3	Nanoparticles technology	Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama	Elsevier, ISBN: 978-0-444-53122-3	First Edition, 2007
4	Biomimetics - Bioinspired Hierarchical-Structured Surfaces for Green Science and	Bharath Bhushan	Springer, ISBN: 978-3-642-25408-6	First Edition, 2012
5	Surface Science: Foundations of Catalysis and Nanoscience	K.W. Kolasinski	Wiley	First Edition, 2002

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

BASICS OF MATERIAL SCIENCE

Course Code	**18NT33**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

In this course, students will get basics of engineering materials and their properties. Also, this course will create awareness among the students about the importance of material science in the field of nanoscience and nanotechnology

Module-1

INTRODUCTION TO MATERIAL SCIENCE: Fundamentals of materials science; Structure: Introduction to microstructure, and nanostructure; Introduction, importance and examples for nanomaterials, biomaterials, electronic, optical, and magnetic materials, ceramic and glass materials, composite materials, polymeric materials, metals and alloys; Introduction and applications of modern engineering materials: shape memory materials, chromic materials (thermo, photo, and electro chromic), rheological fluids, metallic glasses, advanced ceramics; Introduction and applications of Ferroelectricity and ferroelectric materials, Piezoelectricity and piezoelectric materials, pyro-electric materials.

Module-2

ELECTRICAL PROPERTIES OF MATERIALS: Introduction; Measurement of electrical resistivity; Electrical conductivity: conductors, semiconductors, and insulators; Electronic conduction: energy band structures in solids, band and atomic bonding models (for metals, semiconductors, and insulators), drift velocity and electron mobility, factors influencing electrical resistivity of metals, intrinsic semiconduction, extrinsic semiconduction (n-type and p-type), carrier mobility, Hall effect; Semiconductor devices: rectifier and p-n rectifying junction (forward, and reverse bias), transistor, junction transistor and MOSFET; Conduction in ionic materials; Dielectric behaviour: Introduction to electric dipole, capacitance, polarization (electronic, ionic, and orientation); Supper conductors and their applications.

Module-3

OPTICAL PROPERTIES OF MATERIALS: Absorbance and Transmittance: Introduction and measurement of absorbance by absorbance spectroscopy; Index of refraction and Abbe's refractometer; Birefringence and birefrigent materials; Photosensitivity, Photoconductivity, and Photoresistivity; Reflectance and reflectivity, Scattering (Rayleigh, Mie, and geometric) and their applications; Luminescence: types and applications; Fluorescence and its applications; Photonic Materials: principle, and device construction; Liquid crystals and liquid crystal display: molecular orientations, sensitivity to electric field, LCD construction, operation; Photoconducting materials: photoconductive device, construction, materials used, and applications; Photodetectors: characteristics, charged coupled device; Photonic crystals: classification and applications.

Module-4

THERMAL AND MAGNETIC PROPERTIES: Thermal Properties: Introduction; Heat capacity: specific, molar, and volume heat capacity, factors affecting specific heat capacity; Thermal expansion: factors affecting thermal expansion, coefficient of thermal expansion, importance, and applications of thermal expansion property (bimetal, and mercury-in-glass thermometer); Thermal conductivity: Fourier's law, thermal conductance, resistance, transmittance, and admittance, factors affecting thermal conductance.

Magnetic Properties: Magnetic materials, angular momentum; definitions of magnetic dipole, dipole moment, flux, flux density, field strength, magnetization, susceptibility, permeability, relative permeability, Bohr Magneon; Classification of magnetic materials: diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; Hard and soft magnetic materials: comparison, properties and applications; Introduction and applications of Garnets, Magnetoplumbites, Magnetic bubbles, and Magnetic thin films; Spintronics and devices: OMR, GMR, TMR, CMR, advantages, and applications.

Module-5

DEFECTS AND IMPERFECTIONS & MECHANICAL PROPERTIES OF MATERIALS: Defects and Imperfections: Point defects: vacancies, interstitialcy, Schottky defect, Frankel defect, and impurity defects; Line defects: edge dislocation, screw dislocation, Burger's vector, cross slip of a screw dislocation, climb of an edge dislocation; Surface imperfections: grain boundary, tilt boundary, twin boundary.**Mechanical Property of Materials:** Mechanism of elastic action; UTM: Components; Tensile strength, and compression strength: Introduction, concept, testing procedure; Engineering stress and strain, true stress and strain, linear and non-linear elastic properties; Relationship between engineering strain and true strain, engineering stress and true stress; Hardness: Brinell, and Rockwell hardness tests; Fracture: ductile and brittle fracture; Fatigue: mechanism of fatigue; Creep: various stages of creep; Impact strength: Izod and Charpy impact strength tests.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Demonstrate fundamentals of material science;
- CO2: Illustrate electrical and optical properties of materials;
- CO3: Explain thermal and magnetic properties of materials;
- CO4: Analyse mechanical properties of materials;
- CO5: Apply ceramic materials for nano-scale applications

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Material Science	D. John Thiruvadigal, S. Ponnusamy, C. Preferencial Kala, M. Krishna Mohan	Vibrant Publications	First Edition, 2014
2	Fundamentals of Material Science	Prasad Puthiyillam, Savitha Prasad, Narayana Hebbar	LAP-Lambert Academic Publishing, Mauritius, ISBN: 978-3-659-93009-6	First Edition, 2018
Reference Books				
3	Materials Science and Engineering	R. Balasubramaniam	Wiley India Pvt. Ltd, New Delhi	First Edition, 2011
4	The Science & Engineering of Materials	Donald Askeland, Pradeep Fulay, Wendelin Wright	Cengage Learning	Sixth Edition, 2011
5	Materials Science	Thiruvadigal, J. D., Ponnusamy, S. and Vasuhi.P. S.	Vibrant Publications, Chennai	Fifth Edition, 2007

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

PHYSICAL AND CHEMICAL PRINCIPLES OF NANOTECHNOLOGY

Course Code	**18NT34**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To learn the physical and chemical principles involved in the materials and systems.

Module-1

QUANTUM MECHANICS:

Introduction, Planks Hypothesis- Origin of quantum mechanics, Classical v/s Quantum mechanics, experimental and theoretical methods: Dual nature of matter by Debroglie, Uncertainty principle, Localization experiment, Complementarity. Valence bond theory and its applications; Introduction to molecular orbital theory, and computational chemistry.

Module-2

BASICS OF THERMODYNAMICS

Thermodynamics: Introduction, importance and limitations of thermodynamics; thermodynamic terms definition and examples for: system and surroundings, properties of a system, state variables, processes, thermodynamic equilibrium, internal energy, enthalpy, and heat capacity of a system; Zeroth law of thermodynamics.; First law of thermodynamics: definition, mathematical expressions, heat capacity (at constant volume, and constant pressure); Spontaneous process: criteria for spontaneity; Second law of thermodynamics: equivalent forms, entropy and its illustrations, Third law of thermodynamics: definition and

Module-3

LATTICE VIBRATIONS AND BAND THEORY OF SOLIDS

Concept of lattice vibrations and thermal heat capacity, classical, Einstein and Debye theories of molar heat capacity and their limitations.

Band Theory of Solids: Origin of bands, band theory of solids, motion of electron in periodic field of crystal, Kronig-Penny model, Brillion zones, concept of holes, distinction between metal, insulator and semi-conductor.

Module-4

SEMICONDUCTORS AND TUNNELING

Semiconductor: Intrinsic semiconductors, doping and extrinsic semiconductors, simple models for semiconductors, Donor and acceptor levels, p-n junction and rectification, tunnelling and resonant tunnelling.

Tunnelling: Concept of tunnelling, tunnelling through potential barrier, classical vs quantum tunnelling, tunnelling junction, tunnelling diode.

Module-5

COLLOIDAL SYSTEMS

Introduction, Crystalloids and colloids, Classifications of colloids with examples: based on state of aggregation, affinity, and natural dispersed phase. Characteristics of colloidal solutions: Dynamic properties (Brownian motion, diffusion, sedimentation, colligative properties, adsorption, and filterability), Optical properties (visibility, colour, and Tyndall effect), Electrical properties (electrophoresis, and electro-osmosis). Emulsion: introduction, classification, types of emulsions formed on mixing of two partly or completely insoluble liquids, inter-conversion of dispersed phase and medium, characteristics of emulsions, identification of type of emulsion.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Basics of quantum mechanics
- CO2: Basics of thermodynamics
- CO3: Concepts of lattice vibrations and band theory of solids
- CO4: Semiconductors and tunnelling
- CO5: Principles and applications of colloidal systems

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	A textbook of engineering chemistry	Shashi Chawla	Dhanpat Rai & Co, Educational and Technical Publishers, Delhi	First Edition, 2011
2	Basic Principles of Nanotechnology	Wesley C. Sanders	CRC Press, Taylor and Francis group	First Edition, 2018
Reference Books				
3	Solid State Physics	S. O. Pillai	New Age International	First Edition,
4	Introduction to Solid State Physics	C. Kittle	Wiley, India Edition	Seventh Edition, 2007
5	Thermodynamics and Statistical Mechanics	John M. Seddon, Julian	Royal Society of Chemistry	First Edition, 2001

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

FUNDAMENTALS OF BIOSCIENCE

Course Code	**18NT35**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the basic concepts of biochemistry and pathways involved in metabolism.
- To study characteristics of microbes and microbial synthesis of nano materials.

Module-1

CELL BIOLOGY

The Cell: the Basic Unit of Life - Molecular Components of Cells; Cell Metabolism; Cell division – Introduction to Mitosis and meiosis, Eukaryotic and prokaryotic cells, Plant and animal cells.
Structure of cytoplasm, Nucleus, Mitochondria, Ribosome, Golgi bodies, Lysosomes. Endoplasmic Reticulum, Peroxisomes, Chloroplast and Vacuoles. Cell locomotion (Amoeboid, Flagella, Cillar). RBC, WBC.

Module-2

BIOLOGICAL MEMBRANES

Biological membranes: Structure and conformational properties of cell membranes, Singer and Nicholson model, Membrane permeability, fluidity, micelle formation, reverse micelles, properties, passive transport and active transport, facilitated transport, energy requirement, mechanism of Na^+ / K^+, Blood Brain Barrier.

Module-3

MOLECULAR BIOLOGY:

Gene; Genetic Code; Replication; Transcription; translation; Expression of Genetic Information; Genetic Engineering - Recombinant DNA Technology. Catalytic strategies: Protease, Carbonic Anhydrases-. Restriction Enzymes.

Module-4

IMMUNOLOGY:

Immune system: The Cellular Basis of Immunity; Innate immunity and adaptive immunity; The Fine Structure of Antibodies and types; The Functions of Antibodies; T Cell Receptors and Subclasses-MHC Molecules and Antigen Presentation to T Cells-Cytotoxic T Cells-Helper T Cells and T Cell Activation-Selection of the T Cell Repertoire, CD4 cells.

Module-5

BIOMACHINES:

Biomotors: Conversion of Chemical Energy into Mechanical Work by Protein Motors, Brief Description of ATP Synthase Structure – FI motor, a power stroke, pure power stoke, coupling and coordination of motor.
Biomachines: Heart as a pump, Kidney as a filtration Unit, Brain as a data storage device, Stomach as a digester. Biological Sensors in the human body.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Basics of cell biology
- CO2: Concepts of biological membranes
- CO3: Fundamentals of molecular biology
- CO4: Basics of immunology
- CO5: Concepts and applications of biomachines

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Microbiology	Michael J. Pelczar, E. C. S. Chan, Noel R. Krieg	Tata McGraw-Hill Publishing Company Ltd, New Delhi	Fifth Edition, 1958
2	Fundamentals of Bioscience	Abhinaya Nellerichale, Aprrova B. Udupa, Prasad Puthiyillam	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-82263-8	First Edition, 2018
Reference Books				
3	Principles of protein structure	G. Schuiz and R.H. Shrimer	Springer Verlag	First Edition, 1984
4	Principles of Nucleic acid structure	W. Saenger	Springer	First Edition, 1984
5	Physical Chemistry of Membranes:An introduction to the structure and dynamics of biological membranes.	B.L. Siler,Allen and Unwin	The Solomon Press	First Edition, 1985

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

SYNTHESIS AND PROCESSING OF NANOMATERIALS

Course Code	**18NT36**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:
To provide students with the knowledge of techniques used for synthesis and surface modification of nanomaterials.

Module-1

PHYSICAL METHODS:
Ball milling synthesis, Arc discharge, RF-plasma, Plasma arch technique, Inert gas condensation, electric explosion of wires, Ion sputtering method, Laser pyrolysis, Molecular beam epitaxy and electrodeposition. Electro spinning, Physical vapor Deposition (PVD) – Chemcial vapour Deposition (CVD) - Atomic layer Deposition (ALD) – Self Assembly- LB (Langmuir-Blodgett) technique.

Module-2

CHEMICAL METHODS 1:
Chemical precipitation methods- co-precipitation, arrested precipitation, sol-gel method, chemical reduction, photochemical synthesis, electrochemical synthesis, Microemulsions or reverse micelles, Sonochemical synthesis, Hydrothermal, solvothermal, supercritical fluid process, solution combustion process.

Module-3

CHEMICAL METHODS 2:
Spray pyrolysis method, flame spray pyrolysis, gas phase synthesis, gas condensation process, chemical vapor condensation. Fundamental aspects of VLS (Vapor-Liquid-Solid) and SLS (Solution-Liquid-Solid) processes – VLS growth of Nanowires – Control of the size of the nanowires – Precursors and catalysts – SLS growth – Stress induced recrystallization.

Module-4

BIOLOGICAL METHODS:
Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation, Role of plants in nanoparticle synthesis, synthesis of nanoparticles using proteins and DNA templates.

Module-5

SURFACE MODIFICATION OF NANOPARTICLES:
Surface modification of inorganic nanoparticles by organic functional groups - Instantaneous nanofoaming method for fabrication of closed-porosity silica particle- Development of photocatalyst inserted into surface of porous aluminosilicate - Fabrication technique of organic nanocrystals and their optical properties and materialization - Development of new cosmetics based on nanoparticles - Development of functional skincare cosmetics using biodegradable PLGA nanospheres.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Experiment physical techniques used for synthesis and processing of nanomaterials;
- CO2: Analyse chemical methods used for synthesis and processing of nanomaterials;
- CO3: Understand spray pyrolysis methods and fundamentals of VLS
- CO4: Select biological methods used for synthesis and processing of nanomaterials;
- CO5: Test surface modifications of nanoparticels.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanochemistry: A chemical approach to Nanomaterials	Ozin and Arsenault	Roayal Society of Chemistry, Cambridge, UK	First Edition, 2005
2	Synthesis and Processing Techniques	Naveen Kumar JagadapuraRamegowda, Shareefraza J. Ukkund, Prasad Puthiyillam	LAP Lambert Academic Publishing. ISBN: 978-613-9-81532-6	First Edition, 2018
Reference Books				
3	Nanomaterials	A. K. Bandyopadhyay	New Age International Publishers	Second Edition, 2010
4	NANO The Essential, understanding Nanoscience and	T. Pradeep	Tata McGrawHill Publishing Company	First Edition, 2007
5	Nanolithography and patterning techniques in microelectronics	David G. Bucknall	Woodhead Publishing and Maney Publishing	First Edition, 2005

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

SIMULATION AND MODELLING LAB

Course Code	**18NTL37**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To know fundamental skills and knowledge required to use MATLAB for the simulation of engineering systems
- To introduce concepts of numerical methods and introduce Matlab in an Engineering framework

Sl. No.	Experiments
1	Introduction to MAT Lab
2	Use 'if', 'elseif', and 'else' for conditional assignment
3	Switch case and otherwise for excecuting one of several groups of statements
4	Use a while loop to calculate factorial
5	Matrix operations
6	Plotting of UV Vis spetra graph for the synthesis of Ag Nanoparticles
7	Sign wave generation
8	Evaluating mathematical expression using MAT lab code
9	Drawing contours
10	Three dimensional plots
11	Plotting bar charts using MAT lab
12	Solve using MATLAB the following array operations: (a) 1+ [2 3 –1]. (b) 3 x [1 4 8] . (c) [1 2 3] x [0 –1 1]. (d) Square each element of the vector [2 3 1].

Course Outcomes: At the end of the course the student will be able to:

- Students can able to understand the materials behaviour at basic level.
- Students can also learn effect of temperature, electric field and magnetic fields on the different types of materials.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once, and 15% Marks allotted to the procedure part to be made zero.■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

DIGITAL ELECTRONICS LAB

Course Code	**18NTL38**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:
This laboratory course enables students to get practical experience in design, realisation and verification of Demorgan's Theorem, Full/Parallel Adders and Subtractors, Multiplexer using logic gates, Demux and Decoder, Flip-Flops, Shift registers and Counters; and in interfacing microcontroller to Toggle Switch and LEDs, LCD, Stepper Motor, Light dependant resistor (LDR), a relay and buzzer.

Sl. No	Experiments **NOTE:** Use discrete components to test and verify the logic gates. Multisim may be used for designing the gates along with the above.
1	To verify (a) Demorgan's Theorem for 2 variables (b) The sum-of product and product-of-sum expressions using universal gates.
2	To design and implement (a) Full Adder using basic logic gates. (b) Full subtractor using basic logic gates.
3	To design and implement 4-bit Parallel Adder/ subtractor using IC 7483.
4	To realize (a) 4:1 Multiplexer using gates (b) 3-variable function using IC 74151(8:1 MUX) (c) 1:8 Demux and 3:8 Decoder using IC74138
5	To realise the following flip-flops using NAND Gates. (a) Clocked SR Flip-Flop (b) JK Flip-Flop
6	To realize the following shift registers using IC7474 (a) SISO (b) SIPO (c)PISO (d) PIPO
7	To realize the Ring Counter and Johnson Counter using IC7476
8	To realize the Mod-N Counter using IC7490
9	To Interface 8051 to a toggle Switch and 8 LEDs to light up LEDs alternatively when the Switch is ON (in Assembly language).
10	To Interface 8051 to LCD to display a message (in C Language).
11	To Interface 8051 to Stepper Motor to rotate the motor for a given number of steps (C language programming).
12	Interface a Light dependant resistor (LDR), a relay and buzzer to make a light operated switch (in Assembly language).

Course Outcomes: At the end of the course the student will be able to:

- Demonstrate the truth table of various logic gates.
- Design, Test and Evaluate various combinational circuits such as adders, subtractors, multipliers, comparators, parity generators, multiplexers and de-Multiplexers.
- Construct flips-flops, counters and shift registers.
- Develop and Test interfacing of 8051 Microcontroller to various devices.

Conduct of Practical Examination:
1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made

B. E. (Common to all Programmes)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER –II / III / IV

Aadalitha Kannada

Course Code	**18KAK28/39/49**	CIE Marks	100
Teaching Hours/Week (L:T:P)	(0:2:0)		
Credits	01		

ಆಡಳಿತ ಕನ್ನಡ ಕಲಿಕೆಯ ಉದ್ದೇಶಗಳು:

- ಪದವಿ ವಿದ್ಯಾರ್ಥಿಳಾಗಿರುವುದರಿಂದ ಆಡಳಿತ ಕನ್ನಡದ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.
- ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕನ್ನಡ ಭಾಷೆಯ ವ್ಯಾಕರಣದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾ ರಚನೆಯಲ್ಲಿನ ನಿಯಮಗಳನ್ನು ಪರಿಚಯಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾ ಬರಹದಲ್ಲಿ ಕಂಡುಬರುವ ದೋಷಗಳು ಹಾಗೂ ಅವುಗಳ ನಿವಾರಣೆ. ಮತ್ತು ಲೇಖನ ಚಿಹ್ನೆಗಳನ್ನು ಪರಿಚಯಿಸುವುದು.
- ಸಾಮಾನ್ಯ ಅರ್ಜಿಗಳು, ಸರ್ಕಾರಿ ಮತ್ತು ಅರೆ ಸರ್ಕಾರಿ ಪತ್ರವ್ಯವಹಾರದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡಿಸುವುದು.
- ಭಾಷಾಂತರ ಮತ್ತು ಪ್ರಬಂಧ ರಚನೆ ಬಗ್ಗೆ ಅಸಕ್ತಿ ಮೂಡಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾಭ್ಯಾಸ ಮತ್ತು ಸಾಮಾನ್ಯ ಕನ್ನಡ ಹಾಗೂ ಆಡಳಿತ ಕನ್ನಡದ ಪದಗಳ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.

ಪರಿವಿಡಿ (ಪಠ್ಯಪುಸ್ತಕದಲ್ಲಿರುವ ವಿಷಯಗಳ ಪಟ್ಟಿ)

ಅಧ್ಯಾಯ – 1 ಕನ್ನಡಭಾಷೆ – ಸಂಕ್ಷಿಪ್ತ ವಿವರಣೆ.

ಅಧ್ಯಾಯ – 2 ಭಾಷಾ ಪ್ರಯೋಗದಲ್ಲಾಗುವ ಲೋಪದೋಷಗಳು ಮತ್ತು ಅವುಗಳ ನಿವಾರಣೆ.

ಅಧ್ಯಾಯ – 3 ಲೇಖನ ಚಿಹ್ನೆಗಳು ಮತ್ತು ಅವುಗಳ ಉಪಯೋಗ.

ಅಧ್ಯಾಯ – 4 ಪತ್ರ ವ್ಯವಹಾರ.

ಅಧ್ಯಾಯ – 5 ಆಡಳಿತ ಪತ್ರಗಳು.

ಅಧ್ಯಾಯ – 6 ಸರ್ಕಾರದ ಆದೇಶ ಪತ್ರಗಳು.

ಅಧ್ಯಾಯ – 7 ಸಂಕ್ಷಿಪ್ತ ಪ್ರಬಂಧ ರಚನೆ (ಪ್ರಿಸೈಸ್ ರೈಟಿಂಗ್), ಪ್ರಬಂಧ ಮತ್ತು ಭಾಷಾಂತರ.

ಅಧ್ಯಾಯ – 8 ಕನ್ನಡ ಶಬ್ದಸಂಗ್ರಹ.

ಅಧ್ಯಾಯ – 9 ಕಂಪ್ಯೂಟರ್ ಹಾಗೂ ಮಾಹಿತಿ ತಂತ್ರಜ್ಞಾನ.

ಅಧ್ಯಾಯ – 10 ಪಾರಿಭಾಷಿಕ ಆಡಳಿತ ಕನ್ನಡ ಪದಗಳು ಮತ್ತು ತಾಂತ್ರಿಕ/ ಕಂಪ್ಯೂಟರ್ ಪಾರಿಭಾಷಿಕ ಪದಗಳು.

ಆಡಳಿತ ಕನ್ನಡ ಕಲಿಕೆಯ ಫಲಿತಾಂಶಗಳು:

- ಆಡಳಿತ ಭಾಷೆ ಕನ್ನಡದ ಪರಿಚಯವಾಗುತ್ತದೆ.
- ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕನ್ನಡ ಭಾಷೆಯ ವ್ಯಾಕರಣದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡುತ್ತದೆ.
- ಕನ್ನಡ ಭಾಷಾ ರಚನೆಯಲ್ಲಿನ ನಿಯಮಗಳು ಮತ್ತು ಲೇಖನ ಚಿಹ್ನೆಗಳು ಪರಿಚಯಿಸಲ್ಪಡುತ್ತವೆ.
- ಸಾಮಾನ್ಯ ಅರ್ಜಿಗಳು, ಸರ್ಕಾರಿ ಮತ್ತು ಅರೆ ಸರ್ಕಾರಿ ಪತ್ರವ್ಯವಹಾರದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡುತ್ತದೆ.
- ಭಾಷಾಂತರ ಮತ್ತು ಪ್ರಬಂಧ ರಚನೆ ಬಗ್ಗೆ ಅಸಕ್ತಿ ಮೂಡುತ್ತದೆ.
- ಕನ್ನಡ ಭಾಷಾಭ್ಯಾಸ ಮತ್ತು ಸಾಮಾನ್ಯ ಕನ್ನಡ ಹಾಗೂ ಆಡಳಿತ ಕನ್ನಡದ ಪದಗಳು ಪರಿಚಯಿಸಲ್ಪಡುತ್ತವೆ.

ಪರೀಕ್ಷೆಯ ವಿಧಾನ : ನಿರಂತರ ಆಂತರಿಕ ಮೌಲ್ಯಮಾಪನ – ಅಖಇ **(ಅಟಿಣಟಿಣಹಾ ಖಟಿಣಜಾಟಿಚಿಟ ಇತಿಚಿಟಣಚಿಣಾಟಿ):**

ಕಾಲೇಜು ಮಟ್ಟದಲ್ಲಿಯೆ ಆಂತರಿಕ ಪರೀಕ್ಷೆಯನ್ನು 100 ಅಂಕಗಳಿಗೆ ವಿಶ್ವವಿದ್ಯಾಲಯದ ನಿಯಮಗಳು ಮತ್ತು ನಿರ್ದೇಶನದಂತೆ ನಡೆಸತಕ್ಕದ್ದು.

ಪಠ್ಯಪುಸ್ತಕ : ಆಡಳಿತ ಕನ್ನಡ ಪಠ್ಯ ಪುಸ್ತಕ (ಏಚಿಟಿಟಿಚಿಜಚಿ ಜಿಡಿ ೦ಜಟ್ಮಿಡಿಚಿಣಾಟಿ)

ಸಂಪಾದಕರು

ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ

ಪ್ರೊ. ವಿ. ಕೇಶವಮೂರ್ತಿ

ಪ್ರಕಟಣೆ : ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

B. E. (Common to all Programmes)

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER –II & III/IV

Vyavaharika Kannada

Course Code	**18KVK28/39/49**	CIE Marks	100
Teaching Hours/Week (L:T:P)	(0:2:0)		
Credits	01		

Course Learning Objectives:

The course will enable the students to understand Kannada and communicate in Kannada language.

Table of Contents:

Course Outcomes:

At the end of the course, the student will be able to understand Kannada and communicate in Kannada language.

ಪರೀಕ್ಷೆಯ ವಿಧಾನ : ನಿರಂತರ ಆಂತರಿಕ ಮೌಲ್ಯಮಾಪನ – ಅಭಇ **(ಅಡಟಿಣಟಿಣಾ ಖಟಿಣಜಡಿಟಿಚಿಟ ಇತಚಿಟಣಚಿಣಚಟಿ):**

ಕಾಲೇಜು ಮಟ್ಟದಲ್ಲಿಯೆ ಆಂತರಿಕ ಪರೀಕ್ಷೆಯನ್ನು 100 ಅಂಕಗಳಿಗೆ ವಿಶ್ವವಿದ್ಯಾಲಯದ ನಿಯಮಗಳು ಮತ್ತು ನಿರ್ದೇಶನದಂತೆ ನಡೆಸತಕ್ಕದ್ದು.

ಖಿಷಣಛಜಜ (ಪಠ್ಯಪುಸ್ತಕ): ವ್ಯಾವಹಾರಿಕ ಕನ್ನಡ ಪಠ್ಯ ಪುಸ್ತಕ (ಗಿಥಿಚಿತಚಿಟಿಚಿಡಿಟಿಣಚಿ ಏಚಿಟಿಟಿಚಿಜಚಿ ಖಿಷಣಾ ಃಜಜಣ)

ಸಂಪಾದಕರು

ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ

ಪ್ರೊ. ವಿ. ಕೇಶವಮೂರ್ತಿ

ಪ್ರಕಟಣೆ : ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

B. E. Common to all Programmes
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Constitution of India, Professional Ethics and Cyber Law (CPC)
(Mandatory Learning Course: Common to All Programmes)

Course Code	**18CPC39/49**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Course Learning Objectives: This course will enable the students

- To know the fundamental political codes, structure, procedures, powers, and duties of Indian government institutions, fundamental rights, directive principles, and the duties of citizens
- To understand engineering ethics and their responsibilities, identify their individual roles and ethical responsibilities towards society.
- To know about the cybercrimes and cyber laws for cyber safety measures.

Module-1

Introduction to Indian Constitution: The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian constitution, The Making of the Constitution, The Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India. Fundamental Rights and its Restriction and limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and significance in Nation building

Module-2

Union Executive and State Executive: Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, HighCourt and Subordinate Courts, Special Provisions (Articles 370.371,371J) for some States.

Module-3

Elections, Amendments and Emergency Provisions:
Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments- Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44, 61, 73, 74, 75, 86, and 91,94,95,100,101,118 and some important Case Studies. Emergency Provisions, types of Emergencies and its consequences.
Constitutional special provisions: Special Provisions for SC and ST, OBC, Women, Children and Backward Classes.

Module-4

Professional / Engineering Ethics: Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India): Profession, Professionalism, and Professional Responsibility. Clash of Ethics, Conflicts of Interest. Responsibilities in Engineering Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering.

Module-5

Internet Laws, Cyber Crimes and Cyber Laws: Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship. Cybercrimes and enforcement agencies.

Course Outcomes: On completion of this course, students will be able to,
CO 1: Have constitutional knowledge and legal literacy.

CO 2: Understand Engineering and Professional ethics and responsibilities of Engineers.
CO 3: Understand the the cybercrimes and cyber laws for cyber safety measures.

Question paper pattern for SEE and CIE:

- The SEE question paper will be set for 100 marks and the marks scored by the students will proportionately be reduced to 60. The pattern of the question paper will be objective type (MCQ).
- For the award of 40 CIE marks, refer the University regulations 2018.

Textbook:

1. Shubham Singles, Charles E. Haries, and et al: **"Constitution of India, Professional Ethics and Human Rights"** by Cengage Learning India, Latest Edition – 2019.
2. Alfred Basta and et al: **"Cyber Security and Cyber Laws"** by Cengage Learning India - 2018. Chapter – 19, Page No's: 359 to 383.

Reference Books:

1. Durga Das Basu (DD Basu): "**Introduction to the Constitution of India**", (Students Edition.) Prentice –Hall, 2008.
2. M. Govindarajan, S. Natarajan, V. S. Senthilkumar, "**Engineering Ethics**", Prentice –Hall, 2004.

B. E. Common to all Programmes
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - III

ADDITIONAL MATHEMATICS – I

(Mandatory Learning Course: Common to All Programmes)
(A Bridge course for Lateral Entry students under Diploma quota to BE/B. Tech. programmes)

Course Code	**18MATDIP31**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	**0**	Exam Hours	03

Course Learning Objectives:

- To provide basic concepts of complex trigonometry, vector algebra, differential and integral calculus.
- To provide an insight into vector differentiation and first order ODE's.

Module-1

Complex Trigonometry: Complex Numbers: Definitions and properties. Modulus and amplitude of a complex number, Argand's diagram, De-Moivre's theorem (without proof).
Vector Algebra: Scalar and vectors. Addition and subtraction and multiplication of vectors- Dot and Cross products, problems.

Module-2

Differential Calculus: Review of successive differentiation-illustrative examples. Maclaurin's series expansions-Illustrative examples. Partial Differentiation: Euler's theorem-problems on first order derivatives only. Total derivatives-differentiation of composite functions. Jacobians of order two-Problems.

Module-3

Vector Differentiation: Differentiation of vector functions. Velocity and acceleration of a particle moving on a space curve. Scalar and vector point functions. Gradient, Divergence, Curl-simple problems. Solenoidal and irrotational vector fields-Problems.

Module-4

Integral Calculus: Review of elementary integral calculus. Reduction formulae for $\sin^n x$, $\cos^n x$ (with proof) and $\sin^m x \cos^n x$ (without proof) and evaluation of these with standard limits-Examples. Double and triple integrals-Simple examples.

Module-5

Ordinary differential equations (ODE's. Introduction-solutions of first order and first-degree differential equations: exact, linear differential equations. Equations reducible to exact and Bernoulli's equation.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Apply concepts of complex numbers and vector algebra to analyze the problems arising in related area.
- CO2: Use derivatives and partial derivatives to calculate rate of change of multivariate functions.
- CO3: Analyze position, velocity and acceleration in two and three dimensions of vector valued functions.
- CO4: Learn techniques of integration including the evaluation of double and triple integrals.
- CO5: Identify and solve first order ordinary differential equations.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	43rd Edition, 2015
Reference Books				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2015
2	Engineering Mathematics	N. P .Bali and Manish Goyal	Laxmi Publishers	7th Edition, 2007
3	Engineering Mathematics Vol. I	Rohit Khurana	Cengage Learning	1st Edition, 2015

B. E. Common to all Programmes
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

COMPLEX ANALYSIS, PROBABILITY AND STATISTICAL METHODS
(Common to all Programmes)
[As per Choice Based Credit System (CBCS) scheme]

Course Code	**18MAT41**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide an insight into applications of complex variables, conformal mapping and special functions arising in potential theory, quantum mechanics, heat conduction and field theory.
- To develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, design engineering and microwave engineering.

Module-1

Calculus of complex functions: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in cartesian and polar forms and consequences. Construction of analytic functions: Milne-Thomson method-Problems.

Module-2

Conformal transformations: Introduction. Discussion of transformations: $w=z^2$, $w=e^z$, $w=z+\frac{1}{z},(z\neq 0)$. Bilinear transformations- Problems.

Complex integration: Line integral of a complex function-Cauchy's theorem and Cauchy's integral formula and problems.

Module-3

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions- problems (No derivation for mean and standard deviation)-Illustrative examples.

Module-4

Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form- $y=ax+b, y=ax^b$ & $y=ax^2+bx+c.$

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation-problems. Regression analysis- lines of regression –problems.

Module-5

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation and covariance.

Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness of fit.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Use the concepts of analytic function and complex potentials to solve the problems arising in electromagnetic field theory.
- CO2: Utilize conformal transformation and complex integral arising in aerofoil theory, fluid flow visualization and image processing.
- CO3: Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.
- CO4: Make use of the correlation and regression analysis to fit a suitable mathematical model for the statistical data.
- CO5 : Construct joint probability distributions and demonstrate the validity of testing the hypothesis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition,2016
2	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition,2016
Reference Books				
1	Advanced Engineering Mathematics	C.Ray Wylie, Louis C.Barrett	McGraw-Hill	6th Edition 1995
2	Introductory Methods of Numerical Analysis	S.S.Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B.V.Ramana	McGraw-Hill	11th Edition,2010
4	A Textbook of Engineering Mathematics	N.P.Bali and Manish Goyal	Laxmi Publications	6th Edition, 2014
5	Advanced Engineering Mathematics	Chandrika Prasad and Reena Garg	Khanna Publishing,	2018

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

APPLICATIONS OF NANOTECHNOLOGY

Course Code	**18NT42**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

In this subject student will be introduced to applications of nanotechnology in fields of energy, defence, health, communication, transportation, and agriculture.

Module-1

NT IN PHOTOVOLTAICS, BATTERIES, AND FUEL CELLS APPLICATIONS:

Photovoltaics: Introduction, limitations of conventional solar cells, applications of nanotechnology in photovoltaics; Three generation solar cells; Second generation solar cells (CIGS and CdTe): construction, advantages and limitations, Ultrathin nanotechnology solar cells (plastic solar cells): construction, working principle, advantages and limitations. Applications of CNTs in: photovoltaic diode, photo-active layer, transparent electrode, and dye-sensitized solar cells. Batteries, and Fuel cells: Nanobatteries: Introduction, advantages, nanotechnology applications under development; Applications of nanotechnology in Hydrogen fuel cells: production of hydrogen (Tandem cells), storage and transport of hydrogen; improving the efficiency of catalyst, and electrolyte. Applications of nanotechnology in improving the efficiency of DMFC, and SOFC.

Module-2

NT IN ENERGY TRANSMISSIONS, WATER PURIFICATION, AND DEFENSE APPLICATIONS:

Energy transmissions: Applications of nanotechnology to energy production, Nanoscale materials; General energy applications: lighting, heating, transportation, capacitors, power chips; Nanoparticles for energy transmission development: wires and cables; electrical transmission infrastructure: transformers, substations, and sensors.Water purification: Nanooligodynamic metallic particles: oligodynamic effect, mechanism and applications; Photocatalysis: types and applications of nanotechnology in photocatalysis; Desalination: nanofiltration, advantages and limitations, future directions of nanotechnology in membrane process.NT in Defense: Nanotechnology for soldiers: Smart helmets: significance, sensors, optical/IR, RF, and acaustic arrays, antiballistic protection. Smart suits: as armour, for ventilation, for camouflage. Smart equipments: B/C detection, health monitoring and wound healing.

Module-3

NT IN AGRICULTURE, AND FOOD PROCESSING APPLICATIONS:

NT in agriculture applications: Overview of nanotechnology applications in agriculture: Nanoscale carriers, Microfabricated xylem vessels, Nanolignocellulosic materials, Clay nanotubes, Photocatalysis, Nanobarcode technology, Quantum dots for staining bacteria, Biosensors. Nanotechnologies in animal production and health care: Improving feeding efficiency and nutrition, Zoonotic diseases, Animal reproduction and fertility, Nanotechnology and animal waste management. NT in food processing applications: Nanofood, introduction, nanoencapsulation, nanocomposites in food packaging, smart food packaging.

Module-4

NT IN CIVIL ENGINEERING, AUTOMOBILE, AND AEROSPACE APPLICATIONS:

NT in civil engineering applications: Nanotechnology for green building: Introduction, Coatings: self-cleaning coatings, anti-stain coatings, De-polluting surfaces, Scratch-resistant coatings, Anti-fogging and anti-icing coatings, Antimicrobial coatings, UV protection, Anti-corrosion coatings, and Moisture resistance. NT in automobile applications: Functionalities of nanotechnologies (mechanical, geometric effect, electronic/magnetic, optical, and chemical); Applications of NT towards car body shell, car body, car interior, chasis and tyres, electrics and electronics, engine and drive train. NT in aerospace applications: Potential applications in space craft and space structures, Requirements for future space systems, Radiationshielding (Thermal protection), Space elevator, Space elevator (electromagnetic).

Module-5

NANOTECHNOLOGY IN ELECTRONICS, COMPUTER ENGINEERING & PHOTONICS

Introduction to: MOSFET, CMOS, and microchips (DRAM, SRAM, FIFO, EPROM, and PROM). Single electron transistors: introduction, Coulomb blockade, miniature flash memory, and Yano type memory. Quantum mechanical tunneling: RTDs and Esaki diodes. Introduction to spintronics, molecular nanoelectronics, fault tolerant designs, quantum cellular automata, and quantum computing. MEMS and MOEMS: introduction and applications. Introduction to: nanotechnology in photonics, photonic crystals, plasmonics, and spray-on nanocomputers.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Describe applications of nano technology in the photovoltaics, batteries, and fuel cells;
- CO2: Illustrate nano technology in the energy transmissions, water purification, and defense;
- CO3: Explain nano technology in the agriculture and food processing;
- CO4: Describe nano technology in the civil engineering, automobile, and aerospace sector;
- CO5: Research nano technological advances in the electronics, computer engineering, and photonics.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanotechnology, Fundamentals and Applications	Manasi Karkare	I.K. International Publishing, New Delhi. ISBN: 978-81-89866-99-0	First Edition, 2008
2	Applications of Nanotechnology	Prasad Puthiyillam	LAP Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-58532-8	First Edition, 2018
Reference Books				
3	Nanotechnology, Importance & Applications	M.H. Fulekar	I.K. International Publishing House, New Delhi	First Edition, 2011
4	"How helpful is nanotechnology in agriculture? -Review"	Allah Ditta	Advances in natural sciences: Nanoscience and nanotechnology, IOP Publishing	2012

5	Nanotechnology: Synthesis to Applications	Sunipa Roy, Chandan Kumar Ghosh, Chandan Kumar	CRC Press, Taylor & Francis	First Edition, 2018

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

MATERIAL SCIENCE AND ENGINEERING

Course Code	**18NT43**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

In this course, students will understand various concepts related to the material science and engineering, crystal structure, various types of materials, and their uses in developing new technology.

Module-1

INTRODUCTION TO MATERIALS SCIENCE AND ENGINEERING

Functional Classification of Materials; Classification of Materials Based on Structure; Environmental and Other Effects; Materials Design and Selection; The Structure of Materials: Technological Relevance; The Structure of the Atom; The Electronic Structure of the Atom; The Periodic Table and Engineering materials; Atomic Bonding; Binding Energy and Inter-atomic Spacing; Amorphous Materials: Principles and Technological Applications; Lattice, unit cells, Basis, and crystal structure; Points, directions, and planes in the unit cell.

Module-2

CRYSTAL STRUCTURE

Introduction, Differences between Crystalline solids and amorphous solids; Unit cell: Introduction, Miller Indices, high density planes and influence on the behavior of the crystal, Close packing (hexagonal, and cubic), Bravias lattices (in two and three dimensional space), Lattice systems: possible variations, edge lengths, axial angle, and examples; Crystallographic point groups and symmetry operations; Wigner-Seitz cell: Introduction, and construction; Atomic packing: packing fraction, Co-ordination number; Examples of simple crystal structures: NaCl, ZnS and diamond; Symmetry operations, point groups and space groups, Single Crystals, Polycrystalline Materials, Anisotropy.

Module-3

DIFFUSION

Introduction, diffusion Vs bulk flow, diffusion vs osmosis, diffusion Vs drift; Diffusion in the context of different disciplines, Introduction to: atomic diffusion, Eddy diffusion & Eddy motion, Effusion & Graham's law, Photon diffusion, and Passive transport (simple, facilitated, filtration, and osmosis); Mechanism of diffusion in solids (vacancy, and interstitial); Steady state diffusion (Fick's first law); Unsteady state diffusion (Fick's second law); Types of diffusion (self, inter, volume, grain boundary, and surface diffusions); Factors affecting diffusion (diffusion species, temperature, concentration, crystal structure, grain boundary, grain size); Introduction to diffusion in: ionic materials, polymeric materials; Diffusion and material processing (melting and casting, sintering, grain growth, and diffusion bonding); Applications of diffusion.

Module-4

POLYMERIC MATERIALS AND LIQUID CRYSTALS

Introduction, Thermotropic liquid crystals; Lyotropic liquid crystals: lamellar, hexagonal, cubic, and nematic phases; Chemical constitution and liquid crystalline behaviour; liquid crystalline behaviour in homologous series (para-azoxyanisole, para-alkyloxy benzene homologous series); molecular ordering in nematic, cholesteric, smetic, and columnar liquid crystals; Identification of liquid crystals; liquid crystalline polymers; Applications of liquid crystal in displays: introduction, twisted nematic cell transmissive, and reflective displays; types of liquid crystal displays and their applications, applications of chiral liquid crystals in thermography.

Module-5

CERAMIC, AND SMART MATERIALS

Ceramic Materials: Types of ceramics, synthesis and processing of ceramics, classification of ceramics, applications.

Smart materials: Historical background, definition, classification of smart materials, thermo responsive materials, piezoelectric materials, ferrofluids: synthesis and application, electro- rheological fluids (ER) and magneto-rheological fluids (MR) fluids modes of operation and application, smart gel, shape memory alloys.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Describe the physics of materials;
- CO2: Explain the crystal structure of materials;
- CO3:Apply diffusion process for preparing materials;
- CO4:Demonstrate preparation of polymeric materials and liquid crystals;
- CO5: Analyze ceramic and smart materials for engineering and technology applications.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Material Science	D. John Thiruvadigal, S. Ponnusamy, C. Preferencial Kala, M. Krishna Mohan	Vibrant Publications	First Edition, 2014
2	Materials Science and Engineering	V. Raghavan	PHI Learning Pvt. Ltd.	Sixth Edition, 2015
Reference Books				
3	A text book of engineering chemistry	Shashi Chawla	Dhanpat Rai and Co	First Edition, 2011
4	Materials Science & Engineering – A First Course	Raghavan V.	Prentice Hall of India, New Delhi	Fifth Edition, 2005
5	Materials Science and Engineering	Donald R. Askeland, Pradeep P. Fulay, D. K. Bhattacharya	Cengage Learning	Second Indian Reprint, 2010

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

ELECTRONIC INSTRUMENTS AND MEASUREMENTS

Course Code	**18NT44**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- The accuracy and precision, types of errors, statistical, and probability analysis.
- The basic functional concepts of various analog and digital measuring instruments.
- The basic concepts of microprocessor-based instruments.
- The functioning and types of oscilloscopes and signal generators, AC and DC bridges.
- The significance and function of different types of transducers.

Module-1

MEASUREMENT AND ERRORS, AMMETERS, VOLTMETERS & MULTIMETERS, AND MEASURING PROBES: Measurement and Error: Definitions, Accuracy and Precision, Significant Figures, Types of Error, Statistical Analysis, Probability of Errors, Limiting Errors. **Ammeters:** DC Ammeter, Multirange Ammeter, The Ayrton Shunt or Universal Shunt, Requirements of Shunt, Extending of Ammeter Ranges, RF Ammeter (Thermocouple), Limitations of Thermocouple. **Voltmeters & Multimeters:** Introduction, Basic Meter as a DC Voltmeter, DC Voltmeter, Multirange Voltmeter, Extending Voltmeter Ranges, Loading, Transistor Voltmeter, Differential Voltmeter, Average Responding Voltmeter, Peak responding Voltmeter, True RMS Voltmeter. **Measuring Probes:** Introduction, types, introduction to nanoprobes.

Module-2

DIGITAL INSTRUMENTS AND DATA ACQUISITION: Digital Voltmeters: Introduction, RAMP technique, Dual Slope Integrating Type DVM, Integrating Type DVM, Most Commonly used principles of ADC, Successive Approximations. **Data Acquisition:** ADC, DAC, Signal conditioners. **Digital Instruments:** Introduction, Digital Multimeters, Digital Frequency Meter, Digital Measurement of Time, Universal Counter, Decade Counter, Electronic Counter, Digital Tachometer, Digital pH Meter, Digital Phase Meter, Digital Capacitance Meter.

Module-3

OSCILLOSCOPES, AND SIGNAL GENERATORS: Oscilloscopes: Introduction, Basic principles, CRT features, Block diagram of Oscilloscope, Simple CRO, Vertical Amplifier, Horizontal Deflecting System, Sweep or Time Base Generator, Storage Oscilloscope, Digital Readout Oscilloscope.
Signal Generators: Introduction, Fixed and Variable AF Oscillator, Standard Signal Generator, AF sine and Square Wave Generator, Function Generator, Square and Pulse Generator.

Module-4

MEASURING INSTRUMENTS, AND BRIDGES: Measuring Instruments: Output Power Meters, Field Strength Meter, Stroboscope, Phase Meter, Vector Impedance Meter, Q Meter, Megger, Analog pH Meter, Telemetry.
Bridges: Introduction, Wheatstone's bridge, Kelvin's Bridge; AC bridges, Capacitance Comparison Bridge, Inductance Comparison Bridge, Maxwell's bridge.

Module-5

TRANSDUCERS AND ACTUATORS: Introduction, transducers and actuators of electrical, inductive, capacitive, optical, piezoelectric, and photovoltaic. Thermistor, LVDT, Semiconductor photo diode and transistor.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Differentiate accuracy and precision
- CO2: Explain various types of analog and digital measuring instruments.
- CO3: Analyse the performance of the AC and DC bridges.
- CO4: Analyse the performance characteristics of analog and digital measuring instruments.
- CO5: Recognize the importance of lifelong learning in the field of electronic instrumentation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Modern Electronic Instrumentation and Measuring	A. D. Helfrick and W.D.	Pearson	First Edition, 2015
2	Electronics and Instrumentation	B.R. Gupta	S. Chand Limited	First Edition,
Reference Books				
3	Electronic Instrumentation	H. S. Kalsi	McGraw Hill	Third Edition,
4	Electronics and Electrical Measurements	A. K. Sawhney	Dhanpat Rai & Sons	First Edition, 2000
5	Electronic Instrumentation and Measurements	David A. Bell	Oxford University Press	First Edition, 2011

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

BIOCHEMISTRY AND MICROBIOLOGY

Course Code	**18NT45**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the basic concepts of biochemistry and pathways involved in metabolism.
- To study characteristics of microbes and microbial synthesis of nanomaterials.

Module-1

BIOMOLECULES AND BIOLOGICAL MEMBRANES:

Types of chemical reactions, pH, buffers and their properties, concentration of solutions. Brief description of the biomolecules: Carbohydrates; Proteins; Lipids; Nucleic acids (DNA & RNA). Classes of Enzymes with examples. Biological membranes: structure, permeability, properties, passive transport and active transport, facilitated transport, mechanism of Na^+ / K^+, glucose and amino acid transport.

Module-2

BIOENERGETICS AND METABOLISM:

Principle of bioenergetics – Bioenergetics and thermodynamics, phosphoryl group transfer and ATP, Biological oxidation and reduction reaction. Glycolysis, gluconeogenesis, Pentose phosphate pathway of glucose oxidation, Citric acid cycle. Photophosphorylation.

Module-3

STUDY OF MICROORGANISMS:

Scope of microbiology, History of microbiology, origin of life, Prokaryotes and Eukaryotes. Microbial diversity and Taxonomy. Structure, Classification and Reproduction of bacteria, fungi, viruses. General features of Actinomycetes.

Module-4

MICROBIAL GROWTH AND CONTROL OF MICRO ORGANISM:

Growth curve patterns, physical conditions required for growth. Control of microorganism by physical agents (high temperature, low temperature, dessication, osmotic pressure, radiation); Control of microorganism by chemical agents; Antiobiotics and other chemotherapeutic agents.

Module-5

MICROBIAL SYNTHESIS OF NANO MATERIALS:

Biosynthesis of nanoparticles by bacteria and fungi (intracellular and extracellular synthesis). Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation of nanostructured materials by virus - TMV virus; Role of plants in nanoparticle synthesis – marigold, tulsi and aloe vera.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Understand biomolecules and biological membranes
- CO2:Fundamental principles of bioenergetics and metabolism
- CO3:Basics of microbiology
- CO4:Understand microbiological growth and control of microorganisms
- CO5:Understand apply the knowledge of microbial synthesis of nanomaterials

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year

Textbook/s				
1	Microbiology	Michael J Pelczar Jr, Chan ECS, Noel R Krieg	Tata McGraw Hill Publishing co Ltd	First Edition, 2004
2	Biochemistry and Microbiology	Shareefraza J. Ukkund, Abhinaya Nellerichale, Dr. Prasad Puthiyillam	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-83272-9.	First Edition, 2018
Reference Books				
3	Principles of Biochemistry	David L. Nelson, Michael M	WH Freeman and Company	First Edition, 2000
4	NANO The Essential, understanding Nanoscience and Nanotechnology	T. Pradeep	McGraw - Hill Publishing Company Limited	First Edition, 2007
5	Nanobiotechnology- II, More Concepts and Applications	C. A. Mirkin, C. M. Niemeyer	WILEY-VCH, VerlagGmbH&Co	First Edition, 2007

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

ENGINEERING MATERIALS AND SURFACE COATING

Course Code	**18NT46**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the growth in the use of adhesives, especially in ever more technically demanding applications;
- The science and technology of additives, paints and lubricants, and the recent developments in nano technology towards engineering applications of adhesives, paints and lubricants.

Module-1

INTRODUCTION TO ENGINEERING MATERIALS AND SURFACE COATINGS: Adhesives: Introduction, basic terminologies, history of adhesives, functions of adhesives, advantages and disadvantages; Criteria for selection of adhesives; Requirements of a good bond; Factors affecting adhesion strength; Fundamental aspects of adhesion: Forces available (primary chemical bonds, Van der Waals bonds, hydrogen bonds), surfaces, and change of phase; Mechanism of adhesive action: Specific adhesion, Mechanical adhesion, Diffusion adhesion, Electrostatic adhesion; Development of adhesive strength; Factors affecting adhesive action: Physical (interfacial tension, porosity, physical characteristics of adhesive films, effect of temperature, pressure, and time), and Chemical (degree of polymerization of polymeric resins, pH of the medium, polar characteristics, side chains) factors.

Module-2

TYPES AND APPLICATIONS OF ENGINEERING ADHESIVES: Types of glues: types (animal based, plant based, solvent type, and synthetic glues) and examples; Introduction and applications of Non-reactive adhesives (drying adhesives, pressure-sensitive adhesives, contact adhesives, hot-melt adhesives, RTV silicone adhesives) Reactive adhesives (multi-part adhesives, one-part adhesives); Types by origin: natural and synthetic; Structural adhesives: structure properties and applications of epoxies, urethanes adhesives, acrylic adhesives, and phenolic adhesives; Water-based adhesives.

Module-3

ADDITIVES FOR ENGINEERING APPLICATIONS: Introduction; Introduction, examples and importance of: plasticizers, impact modifiers, PVC stabilizers, antioxidants, UV absorbers, optical brightening agents, flame retardants, antistatic agents, smoke suppressants; Processing aids introduction to: viscosity depressants, mould release agents, slip agents, antiblocking agents; Colourants: Introduction, visual and processing requirements; Examples, advantages and limitations of inorganic, and organic pigments.

Module-4

PAINTS AND LUBRICANTS: Paints: Introduction; Components: Vehicle (Binder, thinner), Pigment and filler, Additives; Introduction to colour-changing paint; Varieties of paints: primer and its needs, emulsion paints, varnish resins, properties of shellac, anti-graffiti coatings (sacrificial coating, non-bonding coating), anti-climb paint, anti-fouling paint, luminous paints; paint and environment. Lubricants: Introduction; Properties (Formulation, Additives); Types of lubricants (Base oil groups, Bio-lubricants, Synthetic oils, Solid lubricants, Aqueous lubrication); Applications by fluid types; Glaze (Compacted oxide layer glaze).

Module-5

APPLICATIONS OF NANOTECHNOLOGY IN ADHESIVES, PAINTS, AND LUBRICANT INDUSTRIES

Importance of nano solder particles; nano-conductive Adhesives for nano-electronics, Interconnection: Introduction; nano isotropic conductive adhesives (nano-ICAs): with Ag nanowires, effect of Ag nanoparticles, Ni nano particles, with CNTs; Introduction to inkjet printable nano-ICAs and inks; Introduction to CNT-Based conductive nanocomposites for transparent, conductive, and flexible electronics. Importance of nanotechnology paints; nanomaterials in coatings and their functions (function, examples, and advantages); Potential

environmental benefits of nanomaterials in coating; The nanolubricant approach: Examples and applications.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Apply the concepts of adhesion
- CO2:Apply the knowledge of engineering adhesives
- CO3:Materials for adhesive applications
- CO4:Paints and Lubricants
- CO5:Recent developments in nano technology assisted adhesive, paints, and lubricant industries

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	A textbook of engineering chemistry	Shashi Chawla	DhanpathRai and Co. (PVT) LTD, New Delhi	First Edition, 2011
2	Engineering Materials and Surface Coatings	Dr. Narayana Hebbar N., Aparna Nadumane, Dr. Prasad Puthiyillam	LAP-Lambert Academic Publishing. 978-613-9-95618-0	First Edition, 2018
Reference Books				
3	Adhesive Technology Handbook	Ebnesajjad Arthur H. LandrockSinaEbnesajjad	William Andrew	Second Edition, 2008
4	Electrical Conductive Adhesives with nanotechnologies	Yi Li, Daniel Lu, C.P. Wong	Springer Science+Business Media, LLC	First Edition, 2010
5	Adhesion and Adhesives: Science and Technology	Anthony Kinloch	Springer	First Edition, 1987

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

ELECTRONIC INSTRUMENTATION LAB

Course Code	**18NTL47**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To realize and demonstrate that how different for finding out values of resistance, capacitance and inductance
- To interface sensors and demonstrate the method used in sensing temperature and pressure
- To study the working principle of data acquisition modules in electronic instrumentation

Sl. No.	Experiments
1	To find the value of unknown resistor using Wheatstone bridge.
2	To find the value of unknown capacitance and inductance using Maxwell's bridge
3	To find the value of unknown capacitance using Wein's series and parallel bridge.
4	Measurement of frequency using Lissajous method
5	To study and verify characteristic of variable resistor transducer (strain gauge)
6	To study and verify characteristic of LVDT
7	To study characteristics of temperature transducer like thermocouple, thermistor and RTD with implementation of a small project using signal conditioning circuits like instrumentation amplifier
8	Measurement of pressure using piezoelectric pick up.
9	To interface temperature sensor to Data Acquisition Kit and display the temperature measured.
10	Study of distance measurement using ultrasonic transducer.
11	Measurement of power using ARDUINO
12	Measurement of energy using ARDUINO

Course Outcomes: At the end of the course the student will be able to:

- Students can learn the how to work with electronic instruments and bridge networks for sensing physical parameters
- Students will be able to demonstrate the working of sensors and interfacing circuits in measuring of physical parameters

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

BIOCHEMISTRY AND MICROBIOLOGY LAB

Course Code	**18NTL48**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

Biochemistry is the study of chemical processes in living organisms. It deals with the structures and functions of cellular components such as proteins, carbohydrates, lipids, nucleic acids and other biomolecules. The experiments included in biochemistry lab are fundamentals in nature, dealing with the identification and classification of various carbohydrates, acid-base titration of amino acids, isolation of proteins from their natural sources.

Sl. No.	Experiments
1	Qualitative analysis of glucose
2	Iso-electric precipitation of proteins; casein from milk
3	Qualitative analysis of fructose
4	Separation of amino acids by thin layer chromatography
5	Estimation of saponification value of fats/oils
6	Detection of adulteration in milk
7	Qualitative analysis of amino acids
8	Estimation of iodine value of fat/oil
9	Titration curves of amino acids
10	Estimation of blood glucose by glucose-oxidase method
11	Estimation of acid value from castor oil/coconut oil
12	Quantitative estimation of amino acids by ninhydrin method

Course Outcomes: At the end of the course the student will be able to:

- By the end of the lab students will be able to identify and classify the various carbohydrates, acid-base titration of amino acid, and isolation of protein from their natural sources.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. Common to all Programmes
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

ADDITIONAL MATHEMATICS – II

(Mandatory Learning Course: Common to All Programmes)

(A Bridge course for Lateral Entry students under Diploma quota to BE/B. Tech. programmes)

Course Code	**18MATDIP41**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:1:0)	SEE Marks	60
Credits	**0**	Exam Hours	03

Course Learning Objectives:

- To provide essential concepts of linear algebra, second & higher order differential equations along with methods to solve them.
- To provide an insight into elementary probability theory and numerical methods.

Module-1

Linear Algebra: Introduction - rank of matrix by elementary row operations - Echelon form. Consistency of system of linear equations - Gauss elimination method. Eigen values and Eigen vectors of a square matrix. Problems.

Module-2

Numerical Methods: Finite differences. Interpolation/extrapolation using Newton's forward and backward difference formulae (Statements only)-problems. Solution of polynomial and transcendental equations – Newton-Raphson and Regula-Falsi methods (only formulae)- Illustrative examples. Numerical integration: Simpson's one third rule and Weddle's rule (without proof) Problems.

Module-3

Higher order ODE's: Linear differential equations of second and higher order equations with constant coefficients. Homogeneous /non-homogeneous equations. Inverse differential operators. [Particular Integral restricted to R(x)= e^{ax}, sin ax /cos ax for $f(D)y = R(x)$.]

Module-4

Partial Differential Equations (PDE's): -Formation of PDE's by elimination of arbitrary constants and functions. Solution of non-homogeneous PDE by direct integration. Homogeneous PDEs involving derivative with respect to one independent variable only.

Module-5

Probability: Introduction. Sample space and events. Axioms of probability. Addition & multiplication theorems. Conditional probability, Bayes's theorem, problems.

Course Outcomes: At the end of the course the student will be able to:

CO1: Solve systems of linear equations using matrix algebra.
CO2: Apply the knowledge of numerical methods in modelling and solving engineering problems.
CO3: Make use of analytical methods to solve higher order differential equations.
CO4: Classify partial differential equations and solve them by exact methods.
CO5: Apply elementary probability theory and solve related problems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	43rd Edition, 2015
Reference Books				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2015
2	Engineering Mathematics	N.P.Bali and Manish Goyal	Laxmi Publishers	7th Edition, 2007
3	Engineering Mathematics Vol. I	Rohit Khurana	Cengage Learning	1st Edition, 2015

***** END ******

B.E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

MANAGEMENT AND ENTREPRENEURSHIP

Course Code	**18NT51**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objective:

- To learn various aspects and principles of Management, Planning, and Organization.
- To learn the concepts of Entrepreneurship, and Project Management

Module-1

MANAGEMENT:

Introduction - Meaning - nature and characteristics of Management, Scope and functional areas of management - Management as a science, art or profession Management & Administration - Roles of Management, Levels of Management, Development of Management Thought – early management approaches - Modern management approaches.

Module-2

PLANNING:

Introduction, Nature: rational approach, open system approach, flexibility of planning, and pervasiveness, importance and purpose of planning process - Objectives - Types of plans (Meaning only), Importance of planning, steps in planning, planning premises, Hierarchy of plans, Decision making: types of decisions, decision making process, and environment of decision making.

Module-3

ORGANIZING AND STAFFING

Nature and purpose of organization - Principles of organization - Types of organization - Departmentation - Centralization Vs Decentralization of authority and responsibility - Span of control - MBO and MBE (Meaning only) Nature and importance of Staffing.

Module-4

ENTREPRENEUR:

Meaning of Entrepreneur; Evolution of the Concept, Functions of an Entrepreneur, Types of Entrepreneur, Entrepreneur - an emerging Class. Concept of Entrepreneurship - Evolution of Entrepreneurship, Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship – its Barriers.

Module-5

PREPARATION OF PROJECT:

Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; formulation; Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report; Project Appraisal. Identification of Business Opportunities: Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study.

Course Outcomes: At the end of the course the student will be familiar with:

- Management
- Planning
- Organization
- Entrepreneurship, and
- Project Management

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Principles of Management	P.C. Tripathi, P.N. Reddy	Tata McGraw Hill Publishing Company Limited. New Delhi	First Edition, 2007
2	Dynamics of Entrepreneurial Development & Management	Vasant Desai:	Himalaya Publishing House	First Edition, 2007
3	Entrepreneurship Development	Poornima M Charantimath	– Small Business Enterprises, Pearson Education,	2006
Reference Books				
4	Management Fundamentals: Concepts, Application, Skill Development	Robert Lusier	Thompson	2007
5	Entrepreneurship Development	S. S. Khanka	S. Chand & Co	2007
6	Management	Stephen Robbins	Pearson Education	17th Edition. 2003

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

QUANTUM MECHANICS AND SIMULATION TECHNIQUES

Course Code	**18NT52**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand the basic principles of quantum mechanics and simulation methods.
- To learn the application of the simulation techniques in biology and biomedical fields.

Module-1

PHYSICAL BASIS OF QUANTUM MECHANICS

Experimental background, inadequacy of classical physics, summary of principal experiments and inferences, Uncertainty and Complementarity. Wave packets in space and time, and their physical significance.
Schrodinger wave equation: Development of wave equation: One-dimensional and extension to three dimensions inclusive of forces. Ehrenfest's theorem.

Module-2

THE BASIC PRINCIPLES OF QUANTUM MECHANICS

The fundamental postulates, expectation values and probabilities; quantum mechanical operators, explicit representation of operators, uncertainty principle. Matrix method solution of linear harmonic oscillator. Quantum dynamics: Equations of motion, Schrodinger, Heisenberg and Interaction pictures. Poisson brackets and commutator brackets.

Module-3

QUANTUM COMPUTATIONAL SIMULATION

Turing machines, logic gates, and computers – reversible vs. irreversible computation – Landauer's principle and the Maxwell demon – natural phenomena as computing processes – physical limits of computation – Moore's law – quantum computation – historical development of quantum computation – quantum bits – quantum logic.
(Note: only qualitative approach)

Module-4

SURGICAL SIMULATION AND VIRTUAL ENVIRONMENT

Need, technology, volume image data file, human resources, interface and applications. Virtual environment (VE), technology, applications of VE, advantages of simulators and after effects of VE participation. Surgical nanorobots, Telesurgery, and endoscopy.

Module-5

SIMULATION METHODS AND BIOLOGICAL SYSTEMS

Monte Carlo methods – Introduction, Integration, Simulation, Random Walk, Percolation, Ising Model, Markov.
Simulations of Biological systems - Proteins: Alpha Helix, Beta Sheet, PDB, heme, Dock, DNA: B, Z, A.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Physical basics of quantum mechanics
- CO2:Basic principles of quantum mechanics
- CO3:Basics of Quantum computational simulation
- CO4:Basic principles of surgical simulation and virtual environment for biomedical applications
- CO5:Concepts of simulation methods and biological systems

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introductory Quantum Chemistry	A.K. Chandra	Tata McGraw Hill Publishing Company	First Edition, 1998
2	Stochastic Simulations of Clusters: Quantum Methods in Flat and Curved Spaces	Emanuele Curotto	CRC Press, Taylor and Francis group	First Edition, 2010
Reference Books				
3	Quantum Mechanics	B. K. Agarwal and Hariprakash	Prentice-Hall	First Edition, 1997
4	Medical Informatics: Computer applications in health care and biomedicine	E. H. Shortliffe, G. Wiederhold, L. E. Perreault, L. M. Fagan	Springer Verlag	First Edition, 2000
5	Quantum Mechanics	V. K. Thankappan	Wiley Eastern	First Edition, 1980

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

CHARACTERIZATION TECHNIQUES

Course Code	**18NT53**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To study the basic characterization tools and techniques
- To understand the structural, morphological, and surface composition of nanomaterials
- To understand the electrical measurement devices

Module-1

INTRODUCTION TO CHARACTERIZATION TECHNIQUES:
Introduction to characterization techniques-types of characterization techniques, Basics, Importance, Structural and compositional characterization tools, resolution, resolving power- abbe criterion, Rayleigh criterion. Different types of sources used, electron lenses, scan coils, lens aberrations, electron diffraction-interference, types of detectors used.

Module-2

X-RAY BASED CHARACTERIZATION:
Basic Principles Instrumentation and applications of X-ray diffraction, powder (polycrystalline) and single crystalline XRD techniques; Debye-Scherrer equation. X-ray photoelectron spectroscopy – basic principle, instrumentation, X-ray absorption techniques: introduction to XANES, and EXAFS

Module-3

ELECTRON MICROSCOPY TECHNIQUES:
Principles and applications of Electron beam, Electron beam interaction with matter. Scanning electron microscopy: working principle and application. Transmission electron microscopy: introduction, working and application. Electron-diffraction, introduction to SAED. Atomic Force Microscope: working and types of operating modes. Scanning Tunnelling Microscope: working principle and applications.

Module-4

SPECTROSCOPIC TECHNIQUES:
Principles, operation and applications of UV-VIS Spectrophotometers, IR/FTIR Spectrophotometers, and Raman spectroscopy. Optical microscope: Nanoparticle size measurement by Dynamic light scattering methods, zeta potential.

Module-5

ELECTRICAL MEASUREMENTS:
Introduction to Potentiometry. Basics of Voltammetric techniques: Linear and Cyclic voltammetry. IV, AC and DC electric measurements. Impedence Measurement and analysis.

Course Outcomes: At the end of the course the student will be able to apply the knowledge of:

- CO1: Basics of characterization techniques
- CO2:X-ray based characterization
- CO3:Electron microscopy techniques
- CO4:Spectroscopic techniques
- CO5:Electrical measurements

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Handbook of Nanophase and Nanostructured Materials	Wang, Z.L., Liu, Yi, Zhang, Z	Springer	First Edition, 2002
2	Nanomaterial Characterization	Naveen Kumar JagadapuraRamegowda, Prasad Puthiyillam	LAP-Lambert Academic Publishers, Mauritius. ISBN: 978-3-330-34221-7	First Edition, 2018
Reference Books				
3	Characterization of Nanophase Materials	Zhong Lin Wang	Wiley-VCH	First Edition, 2000
4	Characterization of Nanostructures	SverreMyhra, John C. Rivière	CRC Press	First Edition, 2016
5	Nano Materials Synthesis AndCharacterisation	V. Rajendran	Atlantic Publishers and Distributors	First Edition, 2013

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

SYNTHESIS OF NANOMATERIALS

Course Code	**18NT54**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand methods involved in the synthesis of nano materials
- To learn the techniques which are required for the synthesis of various nano materials

Module-1

SYNTHESIS OF METAL OXIDES AND SEMICONDUCTORS: Introduction, Defining Metal oxide and Semiconductor nanoparticles, Synthesis of Metal Oxide nanoparticles- CdO and AgO nanostructures. Different methods to synthesis CuO (Procedure), comparison, Advantages and Drawbacks CuO nanoparticles, Different methods to synthesis ZnO (Procedure), comparison, Advantages and Drawbacks ZnO nanoparticles, Different methods to synthesis Al_2O_3 (Procedure), comparison, Advantages and Drawbacks Al_2O_3 nanoparticles. Synthesis of Semiconductor nanoparticles- CdS, CdSe, ZnS, PbS, CuS, Cu2S, and TiO_2 (only procedure). Potential Uses of metal oxide and semiconductor nanoparticles.

Module-2

SYNTHESIS OF QUANTUM DOTS AND METAL NANOPARTICLES: Introduction, Defining Nanodimensional Materials, Different methods to synthesis CdSe (Procedure), comparison, Advantages and Drawbacks CdSe quantum dots, Different methods to synthesis ZnS (Procedure), comparison, Advantages and Drawbacks ZnS quantum dots, Different methods to synthesis AgS (Procedure), comparison, Advantages and Drawbacks AgS quantum dots, Metal, Potential Uses for quantum dots.Synthesis of Metal Nano particles - Ag, Au, Pt and Fe nanoparticles.

Module-3

SYNTHESIS OF OXIDE AND NON-OXIDE NANOPARTICLES:Introduction, Defining Oxide and Non-oxide Nanoparticles, Synthesis of Oxide nanoparticles- Magnetite Particles or magnetosomes, $CoFe_2O_4$, $MnFe_2O_4$ and $CoCrFeO_4$nano particulate. Different methods to synthesis Magnetite Particles (Procedure), comparison, Advantages and Drawbacks of Magnetite Particles, Different methods to for the Preparation of Isolated Oxide Nanoparticles- Hydrolysis, Oxidation and solvothermal methods. Potential Uses for Oxide and Non-oxide Nanoparticles.

Module-4

SYNTHESIS OF NANOPOROUS MATERIALS: Introduction, Defining nanoporous materials, Synthesis of Nanoporous materials- Aluminosilicate Zeolites, Metal Phosphates- Aluminium Phosphates, Phosphates of Gallium and Indium, Iron Phosphates, Cobalt and Manganese Phosphates, Copper and Nickel Phosphates, Zirconium and Titanium Phosphates (Procedure only). Advantages and drawbacks of nanoporous materials. Potential Uses of nanoporous materials.

Module-5

BIOSYNTHESIS OF NANOMATERIALS: Introduction, Advantages, disadvantages and applications of biosynthesis route for nanomaterial synthesis. Synthesis of Au and Ag nanoparticles using plant extract. Reduction of Graphite Oxide using plant extract. Synthesis and Assembly of Nanoparticles and Nanostructures Using Bio-Derived Templates, Introduction, Elegant Complexity, Polysaccharides, Synthetic Peptides, and DNA, Proteins, Viruses, Microorganisms. Self-Assembling DNA Nanostructures for Patterned Molecular Assembly, Three-Dimensional (3-D) DNA Nanostructures, Programmed Patterning of DNA Nanostructures.

Course Outcomes: At the end of the course the student will be able to apply the knowledge of:

- CO1: Synthesis of metal oxides and semiconductors
- CO2:Synthesis of quantum dots and metal nanoparticles
- CO3:Synthesis of oxide and non-oxide nanoparticles
- CO4:Synthesis of nanoporous materials
- CO5:Biological synthesis of nanoparticles.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	The Chemistry of Nano materials: Synthesis, Properties and Applications	C. N. R. Rao, A. Muller, A. K. Cheetham	WILEY-VCH Verlag GmbH & Co. KgaA, Weinheim, ISBN 3-527-	First Edition, 2004
2	Synthesis of Nanomaterials	Shareefraza J. Ukkund, Smitha Rai, Prasad Puthiyillam	LAP-Lambert Academic Publishers, Mauritus. ISBN: 978-613-9-82137-2	First Edition, 2018
Reference Books				
3	Nano structures and Nano materials, synthesis, properties	Guozhong Cao	World scientific series in nano science and	First Edition, 2011
4	NANO The Essential, understanding Nano science and	T. Pradeep	Tata McGraw-Hill Publishing Company	First Edition, 2007
5	Nanobiotechnology- II, More Concepts and Applications	C. A. Mirkin, C.M. Niemeyer	WILEY-VCH, VerlagGmbH&Co	First Edition, 2007

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

MICRO FLUIDICS AND NANO FLUIDS

Course Code	**18NT55**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To study basic principles of micro and nano fluids.
- To understand the synthesis advantages and importance of micro and nanofluids.

Module-1

INTRODUCTION TO MICRO FLUIDICS AND NANO FLUIDS: Microfluidics: Introduction, Benefits of size reduction, Benefits of automation and integration, Application areas; PDMS microfluidics: Introduction, PDMS microvalve architectures, elastomeric microfluidic valve, Multilayer device fabrication, Advantages of PDMS devices.

Nano fluids: Properties of nanofluids; thermophysical characteristics of nanofluids and factors affecting; Experimental methods of preparation of nano fluids; Theoretical models for thermal conductivity of nanofluids.

Module-2

BASIC PRINCIPLES OF MICROFLUIDICS: Laminar flow, Peclet number, Pressure driven flow, Electro-osmotic flow, Micropumps: Mechanical micropumps (Peristaltic pump, Centrifugal pump), Non-mechanical micropumps (Electrokinetic pump, Magneto-hydro dynamic (MHD) pump); Micromixers: Active micromixers (Planar laminar bubble mixer, MHD mixer), Passive micromixers (T-type mixers); Soft lithography and PDMS; Detection methods; Applications.

Module-3

MICROFLUIDICS IN BIOMEDICAL RESEARCH: Impact of microfluidics on biomedical research; microfluidics concepts: Laminar versus turbulent flow, Surface and interfacial tension, Capillary forces; Chemotaxis: Introduction, Agar-plate techniques, Two-chamber techniques, Boyden chamber, Bridge chambers, Capillary techniques, Other techniques, A case study in chemotaxis assays; Microfluidic device fabrication (polydimethylsiloxane (PDMS) based, Thermoplastics based, paper based, and wax based); Diagnostics for low-resource settings; Rapidly assaying biofluids with microfluidics; Organ-on-a-chip; Biomimetic blood vessel and capillary networks.

Module-4

MICRO AND NANO EMULSIONS: Emulsion: Appearance and properties, Emulsifiers, Mechanisms of emulsification, Uses; Microemulsions: Definition and History, types of microemulsions, Interaction energies, Packing parameter and microemulsion structures, Hydrophilic−Lipophilic Balance, Phase Inversion Temperature; Surfactant film properties: Ultra-low interfacial tension, Spontaneous curvature; Nano emulsions: Introduction; formation; differences between macro-, micro-, and nano-emulsions; Preparation of nanoemulsions; Droplet size control; Stability: Destabilization mechanisms, Controlling stability of nanoemulsions; Properties: Droplet size and stability, Tunable rheology; Applications of nanoemulsions: in drug delivery, in food industry, as building blocks, in crystallization/pharmaceuticals industry.

Module-5

PREPARATION AND APPLICATIONS OF NANO FLUIDS: Preparation of nano fluids: Preparation of non-metallic nanofluids: Aluminum nitride-nanofluids, Zinc oxide-nanofluids, Titanium dioxide-nanofluids, Silicon dioxide-nanofluids, Copper oxide-nanofluids, Aluminum oxide-nanofluids, Carbon nanotube-nanofluids; Preparation of metallic nanofluids: Gold & silver-nanofluids, Copper-nanofluids. Applications of nanofluids: Heat Transfer Applications, Industrial Cooling Applications, Nuclear Reactors, Extraction of Geothermal Power and Other Energy Sources; Automotive Applications: Nanofluid Coolant, Nanofluid in Fuel, Brake and Other Vehicular Nanofluids; Electronic Applications: Cooling of Microchips, Microscale Fluidic Applications; Biomedical Applications: Nanodrug Delivery, Cancer Theraupetics, Cryopreservation, Nanocryosurgery, Sensing and Imaging; Other Applications: Nanofluid Detergent; Oxide Nanofluids, Metallic Nanofluids, Nanofluids with Carbon Nanotubes.

Course Outcomes: At the end of the course the student will be able to apply the knowledge of:

- CO1: Micro fluidics and Nano fluids
- CO2:Basic principles of micro fluidics
- CO3:Micro fluidics in biomedical research
- CO4:Micro and nano emulsions
- CO5:Preparation and applications of nano fluids

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to Microfluids	PatricTabeling	Oxford U. Press, New York	First Edition, 2005
2	Micro Fluidics and Nano Fluids	Sharel D'Souza, Dr. Savitha Prasad, Dr. Prasad Puthiyillam	LAP-Lambert Academic Publishers. ISBN: 978-613-9-95349-3	First Edition, 2018
Reference Books				
3	Nanofluids: Science and Technology	Sarit K. Das, Stephen U. S. Choi, Wenhua Yu, T. Pradeep	John Wiley & Sons, Inc	First Edition, 2008
4	Microfluidics and Nanofluidics: Theory and Selected Applications	Clement Kleinstreuer	Wiley	First Edition, 2014
5	Theoretical Microfluidics	Henrik Bruus	Oxford Master Series in Physics	First Edition, 2007

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

NANO-PYTHON PROGRAMMING LANGUAGE FOR AUTOMATION

Course Code	**18NT56**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the programming python programming language
- To study implementation of python programmes for automation

Module-1

PYTHON ─ OVERVIEW: History of Python, Python Features.PYTHON ─ BASIC SYNTAX: First Python Program, Python Identifiers, Lines and Indentation, Multi-Line Statements, Quotation in Python, Comments in Python, Using Blank Lines, Waiting for the User, Multiple Statements on a Single line, Multiple Statement Groups as Suites, Command Line Arguments, Accessing Command-Line Arguments, Parsing Command-Line Arguments, getopt.getopt method, Exception getopt.GetoptError.

Module-2

PYTHON ─ BASIC OPERATORS: Types of Operators, Python Arithmetic Operators, Python Comparison Operators, Python, Python Assignment Operators, Python Bitwise Operators, Python Logical Operators, Python Membership Operators, Python Identity Operators, Python Operators Precedence.

Module-3

PYTHON ─ DECISION MAKING: If Statement, If else Statement, The else if Statement, Single Statement Suites

PYTHON ─ LOOPS: While Loop, the Infinite Loop, using else Statement with Loops, Single Statement Suites, For Loop, Iterating by Sequence Index, Using else Statement with Loops, Nested Loops, Loop Control Statements, Break Statement, Continue Statement, Pass Statement.

Module-4

PYTHON ─ NUMBERS and STRINGS: Number Type Conversion, Random Number Functions, Trigonometric Functions, Mathematical Constants. PYTHON ─ STRINGS**:** Accessing values in strings, updating strings, escape characters, string special operators, string formatting operator, triple quotes, unicode string and built-in string methods – capitalize – center – count – decode - encode.

Module-5

PYTHON ─ LISTS& TUPLES

Python Lists Accessing Values in Lists, Updating Lists, Deleting List, Elements Basic List Operations - Indexing, Slicing, and Matrixes, Built-in List Functions – compare – length – max value - min value.

Accessing Values in Tuples, Updating Tuples Deleting Tuple, Elements, Basic Tuples Operations - Indexing, Slicing, and Matrixes, No Enclosing Delimiters, Built-in Tuple Functions – compare –length – max value - min value – tuple.

ROLE OF NANO IN PYTHON

Nano Text Editor - Enable Code Syntax Highlighting for Python, GNU nano – introduction, Invoking, command line options, editor basics, built in help, feature toggles, Nanorc files – syntax highlighting & rebinding keys.

Course Outcomes: At the end of the course the student will be able to apply the knowledge of:

- CO1: Understand the basic syntax of python programming language
- CO2:Understand and apply the basic operation of python programming language
- CO3:Understand and apply the python decision making and python loops
- CO4:Understand and apply the python numbers and strings
- CO5:Understand and apply the python lists and tuples, and correlation of nanotechnology and python programming

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.

- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Python Programming Fundamentals	Lee, Kent D.	Springer	First Edition, 2011
2	Nano - Python Programming Language for Automation	Karthik Nayak, Naveen Kumar J. R., Dr. Prasad Puthiyillam	LAP-Lambert Academic Publishers. ISBN: 978-613-9-95806-1	First Edition, 2018
Reference Books				
3	Beginning Python: Using Python 2.6 and Python 3.1	James Payne	Wiley	First Edition, 2017
4	Learning with Python	Allen Downey, Jeffrey Elkner, Chris Meyers.	Dreamtech Press	First Edition, 2015
5	Effective Python 1: 59 Specific Ways to Write Better Python	Brett Slatkin	Pearson Education	First Edition, 2015

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

NANOMATERIALS SYNTHESIS LAB

Course Code	**18NTL57**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To understand the chemical approach to synthesize nano particles.
- To synthesize nano materials by various chemical methods.

Sl. No.	Experiments
1	Synthesis of Ferro fluids by chemical method
2	Synthesis of Ag metal nano particles by Chemical reduction method
3	Synthesis of TiO_2nano particles by Solvothermal method.
4	Synthesis of Fe_2O_3nano particles by Co-precipitation method
5	Synthesis of Mn_3O_4nano particles by Co-precipitation method
6	Synthesis of CuO nanoparticles by green synthesis
7	Synthesis of ZnS/MoSnano particles by microwave Solvothermal method
8	Synthesis of CuOnano particles by reverse microemulsion method
9	Synthesis of MoS_2nano particles by ultra-sonication method.
10	Synthesis of monodisperse copper nano particles by chemical reduction method.
11	Synthesis of CdS by chemical method
12	Synthesis of nano crystalline AgS
13	Synthesis of ZnO by chemical method
14	Green synthesis of Ag nano particles

Course Outcomes: At the end of the course the student will be able to:

- Learn the different methods to synthesis nano materials.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

CHARACTERIZATION AND MEASUREMENT LAB

Course Code	**18NTL58**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To understand the mechanical, optical, magnetic, thermal, ionic and electromagnetic properties of materials and semiconductors when they experience external fields like electric field and magnetic field.
- To determine the thickness of thin films, working of a solar cell and to identify the unknown materials.

Sl. No	Experiments
1	Determination of electromagnetic properties of N-type and P-type semiconductors.
2	Determination of ionic conductivity of a given sample.
3	Determination of thermal conductivity of thin films.
4	Determination of optical properties of a given sample.
5	Measurement of mechanical properties of a given sample.
6	Determination of magnetic properties of a given liquid sample.
7	Determination of efficiency of a given solar cell.
8	Determination of ultrasonic sound velocity of given liquid samples.
9	Identification of unknown sample by arc spectrum method.
10	Resistivity determination for a semiconductor wafer using Four probe method.
11	To trace the hysteresis loop for a magnetic material.
12	Determination of wavelength of the given LED.
13	Measurement of thickness of a given thin film by air wedge method.

Course Outcomes: At the end of the course the student will be able to:

- Students can able to understand the materials behaviour like mechanical, optical, electrical, thermal, ionic and electromagnetic properties at micro scale level.
- Students can also learn effect of temperature, electric field and magnetic fields on the different types of materials.
- Students can also learn the materials behaviour with respect to the change in voltage and magnetic field.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. (Common to all Programmes)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – V

ENVIRONMENTAL STUDIES

Course Code	**18CIV59**	CIE Marks	40
Teaching Hours / Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Module - 1

Ecosystems (Structure and Function): Forest, Desert, Wetlands, Riverine, Oceanic and Lake. 02 Hrs
Biodiversity: Types, Value; Hotspots; Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.

Module - 2

Advances in Energy Systems (Merits, Demerits, Global Status and Applications)**:** Hydrogen, Solar, OTEC, Tidal and Wind. 02 Hrs
Natural Resource Management (Concept and case-studies): Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading.

Module - 3

Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies)**:** Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution.
Waste Management & Public Health Aspects: Bio-medical Wastes; Solid waste; Hazardous wastes; E-wastes; Industrial and Municipal Sludge.

Module - 4

Global Environmental Concerns (Concept, policies and case-studies):Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.

Module - 5

Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship- NGOs.
Field work: Visit to an Environmental Engineering Laboratory or Green Building or Water Treatment Plant or Wastewater treatment Plant; ought to be Followed by understanding of process and its brief documentation.

Course Outcomes: At the end of the course, students will be able to:

- CO1: Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale,
- CO2: Develop critical thinking and/or observation skills and apply them to the analysis of a problem or question related to the environment.
- CO3: Demonstrate ecology knowledge of a complex relationship between biotic and a biotic component.
- CO4: Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues.

Question paper pattern:

- The Question paper will have 100 objective questions.
- Each question will be for 01 marks.
- Student will have to answer all the questions in an OMR Sheet.
- The Duration of Exam will be 2 hours.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Environmental Studies	Benny Joseph	Tata Mc Graw – Hill.	2nd Edition, 2012

2.	Environmental Studies	S M Prakash	Pristine Publishing House, Mangalore	3rd Edition, 2018
3	Environmental Studies – From Crisis to Cure	R Rajagopalan	Oxford Publisher	2005
Reference Books				
1	Principals of Environmental Science and Engineering	Raman Sivakumar	Cengage learning, Singapur.	2nd Edition, 2005
2	Environmental Science – working with the Earth	G.Tyler Miller Jr.	Thomson Brooks /Cole,	11th Edition, 2006
3	Textbook of Environmental and Ecology	Pratiba Sing, AnoopSingh& PiyushMalaviya	Acme Learning Pvt. Ltd. New Delhi.	1st Edition

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

SURFACE SCIENCE AND THIN FILM TECHNOLOGY

Course Code	**18NT61**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To learn the science of surface and the technological aspects of thin films

Module-1

INTRODUCTION

Introduction to surface, classification, importance. Absorption and adsorption; physic-sorption and chemisorption; factors affecting the adsorption of gases on solid; Adsorption from the Solutions and its importance; applications of adsorption. Colloids: Introduction; differences between colloids and suspension; important properties of true solutions, colloids, and suspensions; types of colloidal solutions and their examples; classification of colloids based on the interactions; Applications of colloidal solutions; colloidal silver and its drawbacks; colloidal gold and its applications. Interfaces: introduction, types, surface energy and energetics, surface tension and effect of surfactants, importance of surface tension in case of nanoparticles, atomic structure of clean surfaces and with adsorbates, surface defects (Terrace, Ledges, Kinks and Adatoms), surface property and bulk property.

Module-2

THIN FILMS AND COATING

Thin films: Introduction, importance; thin film growth modes: Frank-van-der-Merwe mode, Stranski-Krastanow mode, and Volmer-Weber mode. Coating: Functions of coating; Dip coating: Introduction, process, factors affecting. Spin coating: General theory, applications, advantages and disadvantages, special requirements for nanoparticles, thickness equation, speed, duration, DDSC, and SDSC techniques, ultra-low spin speeds and covered drying, spin coating with solvent blends, two step spin coating and edge/corner bead removal, visible assessment of drying and film uniformity, cleaning and wash steps, avoiding a hole& vacuum warping of substrate, spin coating low viscosity solvents, ambient conditions and changes in drying time, incomplete coating of substrate, common spin coating defects.

Module-3

THIN FILM DEPOSITION: PHYSICAL VAPOUR DEPOSITION

Introduction to PVD; vacuum thermal evaporation: resistance heating technique, electron beam heating techniques, Advantages and limitations of vacuum thermal evaporation, applications; Sputter deposition: basic principle, magnetron sputtering, advantages and limitations of sputter deposition, applications; Evaporation (deposition): physical principle, equipment, optimization, applications, comparison.

Module-4

ATOMIC LAYER DEPOSITION AND CHEMICAL BATH DEPOSITION

Atomic layer deposition: Introduction; History; Surface reaction mechanisms: Thermal Al_2O_3 ALD, Metal ALD, Catalytic SiO_2 ALD; ALD applications: Microelectronics applications (Gate oxides, Transition-metal nitrides, Metal films, Magnetic recording heads, and DRAM capacitors), Biomedical applications, and Quality and quality control; Advantages and limitations (Economic viability, Reaction time, and Chemical imitations) of ALD. Chemical bath deposition: Introduction, reaction mechanism, advantages and limitations.

Module-5

ANTI-REFLECTIVE COATING, SELF-CLEANING GLASS, AND NANO INDENTATION

Anti-reflective coating: Introduction, Applications: Corrective lenses, Photolithography; Types: Index-matching, Single-layer interference, Multi-layer interference, Absorbing, Moth eye, and Circular polarizer; Theory: Reflection, Rayleigh's film, Interference coatings, Textured coatings. Self-cleaning glass: Introduction, patterning of hydrophobic surfaces, thin film titania coating, use of titanium dioxide in self-cleaning applications: mechanism, and applications.

Nano indentation: Introduction, process, applications.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Surface science and interfaces,
- CO2: Thin films and coating,
- CO3: Thin film deposition,
- CO4: Atomic layer deposition,
- CO5: Mechanism of anti-reflective coating and self-cleaning glass, and nano indentation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Engineering Coatings: Design and Application	S. Grainger, J. Blunt	Woodhead Publishing Ltd, UK	Second Edition, 1998
2	Surface Science and Thin Film Technology	DeviprasadR. N., Aparna Nadumane, Prasad Puthiyillam	LAP-Lambert Academic Publishers, Mauritius. ISBN: 978-613-9-85635-0	First Edition, 2018
Reference Books				
3	Functional Polymer Films	R. Advincula, W. Knoll	Wiley	First Edition, 2011
4	Handbook of Thin Film Technology	Hartmut Frey, Hamid R. Khan	Springer Science & Business Media	First Edition, 2015
5	Thin Film Technology Handbook	AichaElshabini-Riad, Fred D. Barlow III	Caladonian Rose Books	First Edition, 2000

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

MEMS AND NEMS

Course Code	**18NT62**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand the basic components of MEMS and NEMS
- To study, design the MEMS and NEMS based devices

Module-1

INTRODUCTION

Miniaturization, Integrated Circuits, Microsensors, Microactuators, Thermal MEMS, Micro-Opto Electro mechanical Systems (MOEMS), Magnetic MEMS, Microfluidics, RF MEMS, Packaging.

MICRO SENSORS & ACTUATORS

Principle of sensing and actuation, silicon capacity sensors, piezo-resistive sensors, electrostatic comb drive, magnetic microrelay, piezo-ink jet printer, micromirrors, array sensors, microgrippers, gyroscopes, micro beams and cantilever.

Module-2

TRANSDUCTION PLATFORMS

Introduction - Conductometric and Capacitive Transducers, Optical Waveguide based Transducers, Electrochemical Transducers, Solid State Transducers - Schottky Diode based Transducers - p-n Diodes or Bipolar Junction based Transducers - MOS Capacitor based Transducers, Acoustic Wave Transducers - Cantilever based Transducers - Quartz Crystal Microbalance - Film Bulk Acoustic Wave Resonator.

Module-3

MICROMACHINING

Types of wafers, orientation, Photolithography, Etching methods, Silicon polishing, surface and bulk micromachining, Thin film deposition techniques sputtering, CVD, epitaxial growth, thermal oxidation, wafer bonding.

MEMS MATERIALS

Single crystal silicon, poly silicon, SiO_2, SiN, Germanium based materials, metals, SiC, diamond III-V materials, piezoelectric materials.

Module-4

INTEGRATION OF MEMS DEVICES

Microsystem packaging, packaging technologies, reliability, failure mechanisms, CMOS, stability, transient properties and performance, traceability and calibration, scaling effects, signal amplifiers, transmitters, signal conditioning, basics of control theory, case studies.

Module-5

NANOELECTROMECHANICAL SYSTEMS (NEMS)

Introduction- Nano machining of NEMS based upon electron beam lithography, Nano electromechanical systems fabrication, nano imprint lithography, polymeric nano fibre templates, focused ion beam doping and wet chemical etching, stencil lithography and sacrificial etching, large scale integration, future challenges, applications.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Microsensors and Actuators
- CO2:Transduction platforms
- CO3:Micromachining and MEMS materials
- CO4:Integration of MEMS devices
- CO5:NEMS

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	MEMS	N. P. Mahalik	Tata-McGraw Hill publication	First Edition, 2009
2	MEMS and NEMS	Naveen Kumar JagadapuraRamegowda	LAP-Lambert Academic Publishers, Mauritius. ISBN: 978-3-659-89312-4	First Edition, 2018
Reference Books				
3	Micro & Smart System	V. K. Aatre, G. K. Ananthasuresh, K. J. Vinoy	Wiley India	First Edition, 2010
4	Nanoelectronics and Nanosystems	Karlglosekotter	Springer	First Edition, 2004
5	Micromachines as Tools for Nanotechnology	H. Fujita	Springer	First Edition, 2003

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

NANO-PHOTONICS

Course Code	**18NT63**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand the basic principles of Photonics and its importance
- To study the nano-photonics its fabrication and applications

Module-1

INTRODUCTION TO OPTICS, PHOTONICS AND NANO-PHOTONICS: Different quantities associated with light; Properties of Light; Reflection; Refraction; Interference & Diffraction; Absorption & Scattering. Photonics: Introduction, history; Classical optics, and modern optics; Applications of photonics; Emerging fields of photonics: light sources, photonic systems, Photonic integrated circuits; Organic photonics; Optoelectronics: Introduction, classification with examples.Nanophotonics: Introduction, Principles: Plasmons and metal optics, Near-field optics, and Metamaterials.

Module-2

FOUNDATIONS OF NANO-PHOTONICS: Photons and electrons: similarities and differences, Free space propagation. Confinement of photons and electrons. Propagation through a classically forbidden zone: tunnelling. Localization under a periodic potential: Band gap. Cooperative effects for photons and electrons, Nanoscale optical interactions, axial and lateral nanoscopic localization. Nanoscale confinement of electronic interactions: Quantun confinement effects, nanoscale interaction dynamics, nanoscale electronic energy transfer. Cooperative emissions.

Module-3

FABRICATION AND APPLICATIONS OF PHOTONIC CRYSTALS AND DEVICES: Thermal, mechanical and chemical properties of optical materials; Optical coatings and methods; Optical Filters; Surface quality of optical components. Choices of materials in photonic crystals: semiconductors, amorphous, and polymers, fabrication of photonic crystals structures (1-D, 2-D); Couplers; Waveguides; Photonic crystals fibres; Tunable Photonic crystal filter; High-Q cavites.

Module-4

NANOPHOTONIC DEVICES

Evanescent Wave and an Optical Near Field, Generation and observation of optical near field, Real and virtual exciton–polaritons, Quantitative innovation, Nanophotonics for realizing qualitative innovation. Optical Near-Fields and Effective Interactions, Nanometric Subsystem and Macroscopic Subsystem, Basic Ideas of Nanophotonic Devices, Cellular Automation, Phonon and Near-Field Nanofabrication, Device Operation, Interconnection with Photonic Devices (Optical nano-fountain), nanophotonic devices for room-temperature operation.

Module-5

FUNDAMENTALS OF NANO-PHOTONIC FABRICATION AND NANO-PHOTONIC SYSTEMS: Adiabatic nanofabrication – Non-adiabatic nano-fabrication: near field optical CVD and near field photolithography – Self assembling method via optical near field interactions – Regulating the size and position of nanoparticles using size dependent resonance – Size controlled, position controlled and separation controlled alignment of nanoparticles.

Optical excitation transfer and system fundamentals – Parallel architecture using optical excitation transfer: memory-based architecture, Global Summation Using Near-Field Interactions; Interconnections for nano-photonics – Signal transfer and environment – tamper resistance – Physical Hierarchy in nano-photonics.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Optics, photonics, and nano-photonics
- CO2:Foundations of nano-photonics
- CO3:Fabrication and applications of photonic crystal devices
- CO4:Fundamentals of nano-photonic fabrication
- CO5:Fundamentals of nano-photonic systems

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanophotonics	P N Prasad	John Wiley & Sons	First Edition, 2004
2	Nano-Photonics	Prasad P. Embrandiri, Amrutha Adiga, Savitha Prasad	LAP-Lambert Academic Publishing. ISBN: 978-613-9-95613-5	First Edition, 2018
Reference Books				
3	Nano-Biophotoics	H.Masuhara,S. Kawata,	Elsevier Science	First Edition, 2007
4	Fundamentals of Photonics	BEA Saleh and AC Teich	John Wiley and Sons,NewYork	First Edition, 1993
5	Principals of Nanophotonics (Optics and Optoelectronics)	M. Ohtsu, K. Kobayashi, T. Kawazoe and T. Yatsui	University of Tokyo, Japan.	First Edition, 2003

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

COMPOSITES AND THEIR APPLICATIONS

Course Code	**18NT641**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Composites are a relatively wide used class of materials.
- In this course the students learn about the benefits of combining different materials to a composite to obtain desired properties.
- The motive of this course is to make the students to understand different processing methods, issues, properties and testing methods of different composite materials

Module-1

INTRODUCTION TO COMPOSITES: Definition and Fundamentals of composites and Nanocomposites. Need for composite materials. Classification of composites; Matrix: Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC); Reinforcement: particle reinforced composites, Fibre reinforced composites. Applications of composites. Fibre production techniques for glass, carbon and ceramic fibres.

Module-2

POLYMER MATRIX COMPOSITES: Polymer resins: thermosetting resins, thermoplastic resins; reinforcement fibres: rovings, woven fabrics, non-woven random mats, various types of fibres.
Processing of PMC: hand layup process, spray up process, compression moulding, reinforced reaction injection moulding, resin transfer moulding, Pultrusion, Filament winding, Injection moulding.
Fibre reinforced plastics (FRP), Glass Fibre Reinforced Plastics (GFRP). Applications of PMC in aerospace, automotive industries. Applications of polymer nanocomposites.

Module-3

METAL MATRIX COMPOSITES: Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Applications of Metal matrix nanocomposites. Reinforcements: particles, fibres. Effect of reinforcement: volume fraction, rule of mixtures. Processing of MMC: powder metallurgy process, diffusion bonding, stir casting, squeeze casting, a spray process, Liquid infiltration In-situ reactions, Interface-measurement of interface properties.

Module-4

CERAMIC MATRIX COMPOSITES AND SPECIAL COMPOSITES: Engineering ceramic materials: properties, advantages, limitations, monolithic ceramics, need for CMC. Ceramic matrix: various types of ceramic matrix composites- oxide ceramics, non-oxide ceramics. Reinforcements: particles, fibres, whiskers. Processing of Ceramic Matrix composites: Sintering, Hot pressing, Cold isostatic pressing (CIPing), Hot isostatic pressing (HIPing). Applications of ceramic matrix nanocomposites. Carbon/carbon composites, advantages and limitations of carbon matrix. Carbon fibre – production.

Module-5

LAMINATES AND MECHANICAL PROPERTIES OF COMPOSITES: Laminates: Stacking Sequence Notation; Classification of Laminates: Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates; Mechanical Property Characterization: Strain Measurements, Tensile Testing, Compression Testing; Composite laminate; Joining of Composites: Classification of Joints, Types of Load Carrying Joints, Requirements of the joint design; Mechanically Fastened Joints; Factors affecting Mechanical Performance of composites: Fibre Factors, Matrix Factors, Biological Attack, Moisture and Weathering, Fluids, Temperature Effects, Overheat Conditions, Effect of Ultra Violet Radiation

Course Outcomes: At the end of the course the student will be able to apply the knowledge of:

- CO1: Different composites and fibre production techniques
- CO2: Polymer matrix composites
- CO3: Metal matrix composites
- CO4: Ceramic fabric composites and Special composites

- CO5: Mechanical properties of composites

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Composite Materials: Engineering and Science	Mathews F. L., Rawlings R. D.	Chapman and Hall, London, England	First Edition, 1994
2	Nanocomposite Materials: Synthesis, Properties and Applications	JyotishkumarParameswaranpillai, Nishar Hameed, Thomas Kurian, Yingfeng Yu	CRC Press, Taylor and Francis	First Edition, 2017
Reference Books				
1	Composite materials	Chawla K. K.	Springer – Verlag	Second Edition, 1998
2	Composite materials	Sharma, S.C.	Narosa Publications	First Edition,
3	Introduction to Metal Matrix Composites	Clyne, T. W., Withers, P. J	Cambridge University Press	First Edition, 1993

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

BIOMATERIALS

Course Code	**18NT642**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the fundamental principals in material science and chemistry, and how they contribute to biomaterial development and performance.
- To apply the science and engineering knowledge gained in the course to biomaterial selection and design for specific biomedical uses.

Module-1

FUNDAMENTALS OF BIOMATERIALS SCIENCE: Classes of biomaterials used in medicine, basic properties, medical requirements and clinical significance. Disinfection and sterilization of biomaterials. Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, physical (electrical, optical, magnetic, thermal), chemical and biological properties.

Module-2

ELEMENTS IN CONTACT WITH THE SURFACE OF A BIOMATERIAL: Blood composition, plasma proteins, cells, tissues. Phenomena at the biointerfaces. Molecular and cellular processes with living environment, blood-materials interaction, short and long term reactions to the body.

TESTING OF BIOMATERIALS: in vitro, in vivo preclinical and in vivo clinical tests. Concept of biocompatibility. Definition, Wound healing process-bone healing, tendon healing. Material response: Function and Degradation of materials in vivo. Host response: Tissue response to biomaterials, Effects of wear particles. Testing of implants: Methods of test for biological performance- In vitro implant tests, In vivo implant test methods.

Module-3

PROPERTIES OF IMPLANT MATERIALS: Metals and alloys, ceramics and composites, Stainless steel, Cobalt-Chromium alloys, Titanium based alloys, Nitinol, other metals, metallic Corrosion, Carbons, Alumina, Yittria stabilized zirconia, surface reactive ceramics, resorbable ceramics, composites, analysis of ceramic surfaces. Applications and Biocompatibility case studies of novel materials and alloys.

Module-4

POLYMERS IN BIOMEDICAL APPLICATIONS:

Polyethylene and polypropylene, perfluorinated polymers, acrylic polymers, hydrogels, polyurethanes, polyamides, biodegradable synthetic polymers, silicone rubber, plasma polymerization, micro-organisms in polymeric implants, polymer sterilization. Polymers as biomaterials, heparin and heparin-like polysaccharides, proteoglycans, structure and biological activities of native sulfated glycosaminoglycans, chemically modified glycosaminoglycans, heparin like substances from nonglycosaminoglycan polysaccharides and microbial glycosaminoglycan, surface immobilized heparins. Applications and Biocompatibility case studies of novel polymeric materials.

Module-5

TECHNOLOGIES OF BIOMATERIALS PROCESSING

As implants and medical devices; improvement of materials biocompatibility by plasma processing. Polyurethane elastomers, applications of polymers in medicine and surgery. Skin graft polymers, biodegradable polymers in drug delivery and drug carrier systems. Tissue properties of blood vessels, Treatments of atherosclerosis; Biomechanical design issues pertaining to stents, balloon angioplasty, and pacemakers. Soft Tissue Reconstruction; FDA requirements, standards on the biological evaluation of medical devices (ISO-10993) and implications to applications in human. Practical aspects of biomedical devices: manufacturing, storage quality, regulatory and ethical issues, price of implants and allocation of resources.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Fundamentals of biomaterial science
- CO2:Elements in contact with the surface of a biomaterial, and testing of biomaterials
- CO3:Properties of implant materials
- CO4:Polymers in biomedical applications
- CO5:Technologies of biomaterial processing

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Biomaterials Science	Buddy Ratner Allan Hoffman Frederick Schoen Jack	Academic Press, Elsevier. ISBN: 9780080470368	Second Edition, 2004
2	Biomaterials: The Intersection of Biology and Materials Science	Johnna S. Temenoff, Antonios G. Mikos	Pearson	First Edition, 2009
Reference Books				
1	Polymeric Biomaterials	Severian Dumitriu, Valentin Popa	CRC Press	Third Edition, 2013
2	Biomaterials	Sujata V. Bhat	Springer	First Edition, 2002
3	Polymeric Biomaterials	Piskin, E., Hoffman, Allan S.	Springer	First Edition, 1986

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

MECHANICAL OPERATIONS

Course Code	**18NT643**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Students can learn different techniques and methods to reduce the size, and flow measurements.
- Students can understand the different methods used in the filtration, agitation, mixing and sampling of the minute or micron particles.

Module-1

PARTICLE TECHNOLOGY, EQUIPMENTS AND ANALYSIS

Particle shape, particle size, different ways of expression of particle size, standard screen, screens – ideal and actual screens, differential and cumulative size analysis, specific surface of mixture of particles, Number of particles in a mixture, effectiveness of screen.

Industrial screening equipment, Motion of screen, Gyratory screen, Vibrating screen, Trommels, Sub sieve analysis – Air permeability method, Sedimentation and elutriation methods.

Module-2

FLOW MEASUREMENT

Introduction, Obstruction type flowmeter; Basic Principle, Orifice meter; Corrections, Nozzle Flow meter, velocity flow measurement devices; Pitot Tube, Hot Wire / Film probes, Variable Area flowmeters; Rotameter. Construction of the float, Electromagnetic Flowmeter,Turbine type Flowmeter, Vortex type Flowmeter.

Module-3

FILTRATION

Introduction, Classification of filtration, Cake filtration, Clarification, Batch and continuous filtration, pressure and vacuum filtration, Constant rate filtration, characteristics of filter media, industrial filters, sand filter, Filter press, leaf filter, Rotary drum filter, Horizontal belt filter, Bag filter, Centrifugal filtration – Suspended batch centrifuge, Filter aids, Application of filter aids.

Module-4

AGITATION AND MIXING

Application of agitation, Agitation equipment, Types of impellers – Propellers, Paddles and Turbines, Flow patterns in agitated vessels, Prevention of swirling, Standard turbine design, Power correlation and power calculation, Mixing of solids, Types of mixers – Change can mixers, Muller mixers, Mixing index, Ribbon blender, Internal screw mixer, Tumbling mixer.

Module-5

SAMPLING, STORING AND CONVEYING OF SOLIDS

Sampling of solids, storage of solids, Open and closed storage, Bulk and bin storage, Conveyors – Belt conveyor, Chain conveyor, Apron conveyor, Bucket conveyor, Bucket elevator, Screw conveyor, Slurry transport, Applications of fluidization, Pneumatic conveying.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: The particle size analysis by different models and methods
- CO2: Different types of flow measurement methods and techniques.
- CO3:The filtration methods, classification, importance and applications
- CO4: The agitation and mixing aspects and applications.
- CO5: The sampling, storing of solid samples.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year

Textbook/s				
1	Unit Operations of Chemical Engineering	McCabe W.L.	McGraw Hill International, New York.	Fifth Edition, 2000
2	Mechanical Operations	Shareefraza J. Ukkund, Shrinivasa D. Mayya, Prasad Puthiyillam	LAP-Lambert Academic Publishers, Mauritius. ISBN: 978-613-9-82579-0	First Edition, 2018
Reference Books				
1	Unit Operations	Brown. G.G.,	CBS Publishers, New Delhi	First Edition, 1995
2	Principles of Unit Operations	Foust A. S.	John Wiley and Sons, New York	Third Edition, 1977
3	Perry's Chemical Engineers' Handbook	Perry R and Green W.D.	McGraw Hill, International, New York	First Edition, 2000

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

OPEN ELECTIVE - A

INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY

Course Code	**18NT651**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To introduce the concept of nanoscience and nanotechnology.
- To understand the importance and applications of nanotechnology.
- To know the physical and chemical methods of synthesis of nanomaterials.
- To learn about different nanomaterials and their applications.

Module-1

INTRODUCTION AND SCOPE

History, background and interdisciplinary nature of nanoscience and nanotechnology, challenges of Rechard Feynman, scientific revolutions, nanosized effects surface to volume ratio, examples of surface to volume ratio, atomic structure, Bohr atomic model, molecules and phases, introduction to classical physics and quantum mechanics, importance of nanoscale materials and their devices.

Module-2

CLASSIFICATION OF NANOSTRUCTURES

Zero dimensional, one-dimensional and two dimensional nanostructure materials - classification of solids: conductor, semiconductors, insulator, types of semiconductor, doping, diodes, current flow in semiconductors, ceramics and nanocomposites, quantum size effect(QSE) in 1D, 2D, 3D nanomaterials, quantum dots, nanowires, nanotubes, nanosheets, top down and bottom up approach.

Module-3

SYNTHESIS OF NANOMATERIALS – PHYSICAL METHODS

Ball milling synthesis, Arc discharge, RF-plasma, Plasma arch technique, Inert gas condensation, electric explosion of wires, Ion sputtering method, Laser pyrolysis, Molecular beam epitaxy and electrodeposition. Electro spinning, Physical vapor Deposition (PVD) – Chemcial vapour Deposition (CVD) - Atomic layer Deposition (ALD) – Self Assembly- LB (Langmuir-Blodgett) technique.

Module-4

SYNTHESIS OF NANOMATERIALS - CHEMICAL METHODS

Spray pyrolysis method, flame spray pyrolysis, gas phase synthesis, gas condensation process, chemical vapor condensation.Fundamental aspects of VLS (Vapor-Liquid-Solid) and SLS (Solution-Liquid-Solid) processes – VLS growth of Nanowires – Control of the size of the nanowires – Precursors and catalysts – SLS growth – Stress induced recrystallization.

Module-5

ENGINEERING APPLICATIONS OF NANOTECHNOLOGY

NT in civil engineering applications: Nanotechnology for green building: Introduction, Coatings: self-cleaning coatings, anti-stain coatings, De-polluting surfaces, Scratch-resistant coatings, Anti-fogging and anti-icing coatings, Antimicrobial coatings, UV protection, Anti-corrosion coatings, and Moisture resistance. NT in automobile applications: Functionalities of nanotechnologies (mechanical, geometric effect, electronic/magnetic, optical, and chemical); Applications of NT towards car body shell, car body, car interior, chasis and tyres, electrics and electronics, engine and drive train. NT in aerospace applications: Potential applications in space craft and space structures, Requirements for future space systems, Radiation shielding (Thermal protection), Space elevator, Space elevator (electromagnetic).

Course Outcomes: At the end of the course the student will be able to:

- CO1: Understand the concepts of Nanoscience and Nanotechnology.
- CO2: Understand the classification of nanostructures.
- CO3: Understand physical methods of synthesis of nanomaterials.

- CO4: Understand the chemical methods of synthesis of nanomaterials.
- CO5: Engineering applications of nanomaterils.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanophysics and Nanotechnology - An Introduction to Modern Concepts in Nanoscience	Edward L. Wolf	John Wiley & Sons	Second Edition, 2006
2	Foundations of Nanoscale Science and Technology	Shareefraza J. Ukkund, Prasad Puthiyillam	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-958649-3	First Edition, 2018
Reference Books				
3	Nanochemistry: A chemical approach to Nanomaterials	Ozin and Arsenault	Roayal Society of Chemistry, Cambridge, UK	First Edition, 2005
4	Synthesis and Processing Techniques	Naveen Kumar JagadapuraRamegowda, Shareefraza J. Ukkund, Prasad Puthiyillam	LAP Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-81532-6	First Edition, 2018
5	Applications of Nanotechnology	Prasad Puthiyillam	LAP Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-58532-8	First Edition, 2018

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

OPEN ELECTIVE - A

NANOMATERIALS AND THEIR APPLICATIONS

Course Code	**18NT652**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

To understand the importance of nanomaterials and their applications in Photovoltaics, Batteries, and Fuel Cells; Electrical and electronics; Chemical industry; Food industry and Agriculture; Textile and Cosmetics

Module-1

NANOMATERIALS FOR PHOTOVOLTAICS, BATTERIES, AND FUEL CELLS APPLICATIONS: Photovoltaics: Introduction, limitations of conventional solar cells, applications of nanotechnology in photovoltaics; Three generation solar cells; Second generation solar cells (CIGS and CdTe): construction, advantages and limitations, Ultrathin nanotechnology solar cells (plastic solar cells): construction, working principle, advantages and limitations. Applications of CNTs in: photovoltaic diode, photo-active layer, transparent electrode, and dye-sensitized solar cells. Batteries, and Fuel cells: Nanobatteries: Introduction, advantages, nanotechnology applications under development; Applications of nanotechnology in Hydrogen fuel cells: production of hydrogen (Tandem cells), storage and transport of hydrogen; improving the efficiency of catalyst, and electrolyte. Applications of nanotechnology in improving the efficiency of DMFC, and SOFC.

Module-2

NANOMATERIALS FOR ELECTRICAL AND ELECTRONICS APPLICATIONS

Energy transmissions: Applications of nanotechnology to energy production, Nanoscale materials; General energy applications: lighting, heating, transportation, capacitors, power chips; Nanoparticles for energy transmission development: wires and cables; electrical transmission infrastructure: transformers, substations, and sensors. Single electron transistors: introduction, Coulomb blockade, miniature flash memory, and Yano type memory. Quantum mechanical tunneling: RTDs and Esaki diodes. Introduction to spintronics, molecular nanoelectronics, fault tolerant designs, quantum cellular automata, and quantum computing. MEMS and

Module-3

NANOMATERIALS FOR CHEMICAL INDUSTRY: Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – TiO_2 Nanoparticles for water purification- Photocatalytic mechanism, general pathways and kinetics- Treatment of Arsenic- Removal of Heavy metal ions by Iron and polymeric based nanoparticles- Magnetic Nanoparticles Nanoscale carbon for contaminant separation -Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors

Module-4

APPLICATIONS OF NANOMATERIALS IN AGRICULTURE AND FOOD TECHNOLOGY

NT in agriculture applications: Overview of nanotechnology applications in agriculture: Nanoscale carriers, Microfabricated xylem vessels, Nanolignocellulosic materials, Clay nanotubes, Photocatalysis, Nanobarcode technology, Quantum dots for staining bacteria, Biosensors. Nanotechnologies in animal production and health care: Improving feeding efficiency and nutrition, Zoonotic diseases, Animal reproduction and fertility, Nanotechnology and animal waste management. NT in food processing applications: Nanofood, introduction, nanoencapsulation, nanocomposites in food packaging, smart food packaging.

Module-5

NANOMATERIALS FOR TEXTILES AND COSMETICS APPLICATIONS: Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – Polymer nanofibers - Nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers -Bionics– Swim-suits with shark-skin-effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles; Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear

Cosmetics – Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) –Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics

Course Outcomes: At the end of the course the student will be able to identify and apply different nanomaterials for the following applications:

- CO1: Photovoltaics, Batteries, Fuel Cells
- CO2:Electrical and electronics
- CO3:Chemical industry
- CO4:Food industry and Agriculture
- CO5:Textile and Cosmetics

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanotechnology, Fundamentals and Applications	Manasi Karkare	I.K. International Publishing, New Delhi. ISBN : 978-81-89866-99-0	First Edition, 2008
2	Applications of Nanotechnology	Prasad Puthiyillam	LAP Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-58532-8	First Edition, 2018
Reference Books				
3	Nanotechnology, Importance & Applications	M.H. Fulekar	I.K. International Publishing House, New Delhi	First Edition, 2011
4	"How helpful is nanotechnology in agriculture?-Review"	Allah Ditta	Advances in natural sciences: Nanoscience and nanotechnology, IOP Publishing	2012
5	Nanotechnology: Synthesis to Applications	Sunipa Roy, Chandan Kumar Ghosh, Chandan Kumar Sarkar	CRC Press, Taylor & Francis	First Edition, 2018

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

OPEN ELECTIVE - A

NANOMATERIALS SYNTHESIS AND CHARACTERIZATION TECHNIQUES

Course Code	**18NT653**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide students with the knowledge of techniques used for synthesis and characterization of nanomaterials.

Module-1

TOP DOWN APPROACHES

Synthesis and nanofabrication, Bottom-Up versus Top-Down; Top-down approach with examples, Ball milling synthesis, Arc discharge, RF-plasma, Plasma arch technique, Inert gas condensation, electric explosion of wires, Ion sputtering method, Laser pyrolysis, Molecular beam epitaxy and electrodeposition. Electro spinning, Physical vapors Deposition (PVD) – Chemical vapour Deposition (CVD) - Atomic layer Deposition (ALD).

Module-2

BOTTOM UP APPROACHES

Chemical precipitation methods-co-precipitation, arrested precipitation, sol-gel method, chemical reduction, photochemical synthesis, electrochemical synthesis, Microemulsions or reverse micelles, Sonochemical synthesis, Hydrothermal, solvothermal, supercritical fluid process, solution combustion process, spray pyrolysis method, flame spray pyrolysis, chemical vopour synthesis, gas phase synthesis, gas condensation process, chemical vapour condensation.

Module-3

BIOLOGICAL SYNTHESIS

Biosynthesis of nano particles by bacteria and fungi (intracellular and extracellular synthesis). Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation of nanostructured materials by virus - TMV virus; Synthesis process and application, Role of plants in nanoparticle synthesis – marigold, tulsi and aloevera.

Module-4

CHARACTERIZATION TECHNIQUES - I

Introduction, Structural and compositional characterization- principles and applications of X-ray diffraction, X-ray photoelectron spectroscopy, Energy dispersive X-ray analysis, electron diffraction. Optical microscopy- Use of polarized light microscopy – Phase contrast microscopy – Interference Microscopy – hot stage microscopy - surface morphology – Etch pit density and hardness measurements.

Module-5

CHARACTERIZATION TECHNIQUES - II

Scanning Electron Microscopy (SEM): Principle, Components, Advantages, Disadvantages and Applications, Transmission Electron Microscopy (TEM): Principle, Components and Applications, Atomic Force Microscopy (AFM): Principle, Components and Applications, Scanning Tunneling Microscopy (STM): Principle, Components and Applications, microstructure studies and analysis. Nano size measurement by light scattering methods.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Experiment Top-down approaches: physical techniques used for synthesis and processing of nanomaterials
- CO2:Analyze Bottom-Up Approaches: chemical methods used for synthesis and processing of nanomaterials
- CO3:Select biological methods used for synthesis and processing of nanomaterials;
- CO4:Test Characterization of nanoparticles
- CO5:Electron-microscopy characterization

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Handbook of Nanophase and Nanostructured Materials	Wang, Z.L., Liu, Yi, Zhang, Ze	Springer	First Edition, 2002
2	Characterization of Nanophase Materials	Zhong Lin Wang	Wiley-VCH	First Edition, 2000
Reference Books				
3	Nanomaterial Charatcerization	Naveen Kumar JagadapuraRamegowda, Prasad Puthiyillam	LAP-Lambert Academic Publishers, Mauritius. ISBN: 978-3-330-34221-7	First Edition, 2018
4	Characterization of Nanostructures	Sverre Myhra, John C. Rivière	CRC Press	First Edition, 2016
5	Nano Materials Synthesis And Characterisation	V. Rajendran	Atlantic Publishers and Distributors	First Edition, 2013

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

NANOMATERIAL SURFACE CHARACTERIZATION AND THIN FILM LAB

Course Code	**18NTL66**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- To study about the surface characterization of nanomaterials
- To learn about the thin film device fabrication.
- To prepare nanocomposite thin films.

Sl. No.	Experiments
1	Calculate the wear rate from wear track depth 2D images.
2	Calculation of the Area under the curve for a specified element/compound for a Raman data by filling
3	Analyse of the amount of elastic and plastic deformation from a Nanohardness test (NHT) data using origin pro.
4	Analyse the average particle size and shape of the particles for a given image using image J software. (Average Diameter of Spherical shape particles, Average length and width of a rod/wire shaped).
5	Get the tafel plot for a given Electrochemical potential studies sample data and find out • β_a and β_c • E_{corr} and I_{corr} • Corrosion resistance (CR) in mmpy.
6	Get the Raman plot from the given data and find out the FWHM and Sp^3/Sp^2 ratio for DLC (Diamond like carbon) coated sample.
7	Get the COF vs Sliding Distance & wear loss vs sliding distance for a given two different samples data for wear studies and analyse, calculate the sliding distance manually.
8	Get the XRD peaks from the given ASCII file and find the FWHM and calculate interplanar distance "d" using Bragg's equation.
9	Thin film Dye Sensitised Solar cell fabrication
10	Thin film Gas and Bio-chemical sensor fabrication
11	Thin film nanomaterial based super capacitor
12	Preparation of thin film ceramic based nanocomposites, metal-polymer nanocomposites, metal-biopolymer nanocomposites

Course Outcomes: At the end of the course the student will be able to:

- Prepare nanomaterials, and their composites.
- Prepare nanotechnology-based devices
- Characterize the nanomaterials

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

MEMS SIMULATION LAB

Course Code	**18NTL67**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

To understand the simulation programmes for the MEMS characteristics; To study about MEMS devices and calculations by using MEMSolver software; To understand the simulation at atomic and molecular level by using softwares; To study about the nucleic acids, proteins, superimposition of molecules and building the phylogenetic tree.

Sl. No.	Experiments
1	Calculation & Simulation of burst pressure, non-linearity & plot graph for sensitivity for Piezoresitive pressure sensor with a (i) square diaphragm, (ii) round diaphragm, (iii) rectangular diaphragm.
2	Calculation & Simulation of maximum acceleration, maximum sensitivity, non-linearity & plot graph for acceleration V/S displacement of capacitive accelerometer for static signal.
3	Calculation & Simulation of (i) maximum acceleration, maximum displacement & plot graph for acceleration V/S displacement of capacitive accelerometer for step signal, (ii) time duration of pulse & plot graph for acceleration V/S time of capacitive accelerometer for pulse signal, (iii) output current, output voltage, piezoelectric capacitance & plot graph for output V/S frequency of piezoelectric accelerometer under longitudinal load.
4	Calculation & Simulation of (i) output current, output voltage, piezoelectric capacitance & plot graph for output V/S frequency of thin film based piezoelectric accelerometer, (ii) pull in voltage, actuation force, balanced displacement & plot graph for force V/S displacement of parallel plate actuator for normal
5	Calculation & Simulation of (i) balanced displacement, actuation force, normal spring constant & plot graph for voltage V/S displacement of comb drive actuator for lateral motion, (ii) tip deflection, tip force & plot graph for deflection V/S film thickness of cantilever based bimetallic thermal actuator, (iii) deflection, tip force & plot graph for deflection V/S beam length of thermal bimorph actuator
6	Calculation & Simulation of maximum deflection, response time, maximum temperature change & plot graph for transient response of thermal bent beam actuator.
7	Calculation & Simulation of (i) actuator displacement, actuator force, electric field strength & plot graph for actuator force of longitudinal piezoelectric actuator, (ii) actuator displacement, actuator force, electric field strength & plot graph for actuator displacement of transverse piezoelectric actuator.
8	Using QuantumWise - Virtual NanoLab Software (i) Modelling metal–semiconductor contacts: The Ag–Si interface, (ii) Resistivity calculations using the MD-Landauer method, (iii) Spin-orbit transport calculations: Bi2Se3 topological insulator thin-film device, (iv) Opening a band gap in silicene and bilayer graphene with an electric field
9	Using QuantumWise - Virtual NanoLab Software (i) Building molecule–surface systems: Benzene on Au (111), (ii) Spin-dependent Bloch states in graphene nanoribbons, (iii) Exploring graphene - Build a graphene sheet - Build a CNT - Transmission spectrum of a GNR, (iv) Twisted nanoribbon - Transmission spectrum - Buckling a graphene sheet
10	Sequence retrieval from nucleic acid and protein data base using NCBI, Multiple alignment of sequence and pattern determination by NCBI and Clustal Omega Prosite software
11	Evolutionary studies / phylogenetic analysis by phylowin software and Visualization by TreeView software; Secondary structure prediction of proteins by Sopma software
12	Identification of functional sites in gene / genome by Gen Sean and ORF finder software; Super imposition of molecular structures and calculation of RMSD by SPDBV software; PDB structure retrieval and visualization; analysis of homologous structure by RASMOL software

Course Outcomes: At the end of the course the student will be able to:

- Understand the simulation programmes for the MEMS characteristics.
- Study about MEMS devices and calculations by using MEMSolver software.
- The simulation at atomic and molecular level by using softwares.
- About the nucleic acids, proteins, superimposition of molecules and building the phylogenetic tree.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VI

MINI PROJECT

Course Code	**18NTMP68**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:0:2)	SEE Marks	60
Credits	02	Exam Hours/Batch	03

Course Learning Objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas. ■

Mini-Project: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course Outcomes: At the end of the course the student will be able to:

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it. ■

CIE procedure for Mini - Project:

The CIE marks awarded for Mini - Project, shall be based on the evaluation of Mini - Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.The marks awarded for Mini - Project report shall be the same for all the batch mates. ■

Semester End Examination

SEE marks for the mini-project shall be awarded based on the evaluation of Mini-Project Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University. ■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

INTERNSHIP

All the students admitted to III year of BE/B. Tech. shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail and shall have to complete during subsequent University examinations after satisfying the internship requirements.

Course Code	Refer to VIII semester scheme	CIE Marks	40
Duration of internship	04 weeks	SEE Marks	60
Credit		Exam Hours/ Batch	03

Course Learning Objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc. The objective are further,

- To put theory into practice.
- To expand thinking and broaden the knowledge and skills acquired through course work in the field.
- To relate to, interact with, and learn from current professionals in the field.
- To gain a greater understanding of the duties and responsibilities of a professional.
- To understand and adhere to professional standards in the field.
- To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
- To identify personal strengths and weaknesses.
- To develop the initiative and motivation to be a self-starter and work independently.■

Internship: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.

Seminar: Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident. ■

Course Outcomes:

At the end of the course the student will be able to:

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learnt to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.
- Expand intellectual capacity, credibility, judgment, intuition.
- Acquire the knowledge of administration, marketing, finance and economics. ■

Continuous Internal Evaluation

CIE marks for the Internship shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculties from the department with the senior most acting as the Chairman.

The CIE marks awarded shall be based on the evaluation of Internship Report, Presentation skill and Question and Answer session in the ratio 50:25:25. ■

Semester End Examination

SEE marks for the Internship shall be awarded based on the evaluation of Internship Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University. ■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

NANO-ELECTRONICS

Course Code	**18NT71**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(4:0:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To understand the basic concepts of nano-electronics
- To learn the techniques which are used for develop devices which are developed by nanotechnology.

Module-1

QUANTUM ELECTRONICS AND SINGLE ELECTRON TRANSISTOR

Introduction, Quantum Electronic Devices, Examples of quantum Electronics Device – Short Channel MOS transistor, Split Gate Transistor, Electronic spin Transistor, Quantum Cellular Automata and Quantum dot array.

Single electron transistor: principles of SET, SET circuit design and Applications, molecular SETs, and molecular electronics

Module-2

CNT AND NANOELECTRONIC DEVICES

Carbon Nanotube: Introduction, properties, characterization and application of carbon nano tube.

Introduction to Nano devices: Graphene transistors, Nanowire FET, quantum Dot devices, Quantum Dot FET, Organic transistors, CNTFET, FinFETs.

Module-3

CARBON NANOTUBE FETS

Introduction, Single Wall Nano Tube (SWNT), Double Wall Nano Tube (DWCNT), IV characteristics of P-CNTFET, N-CNTFET, small signal model for CNTFET, electrical equivalent of CNTFET, design of inverter using CNTFET, CNTFET based digital and analog circuits, memory cell using CNTFET.

Module-4

NANO ELECTRONICS WITH TUNNELING DEVICES

Tunnelling Diode, Resonant Tunnelling Diode (RTD), Three Terminal Resonant Tunnelling devices, Technology of RTD, Digital Circuit Based On RTDs – Memory Application, Basic Logic Circuits, Dynamic Logic Circuits and Digital circuits Based on the RTBT.

Module-5

TUNNEL JUNCTIONS

Tunnel junctions and applications of tunnelling, tunnelling through potential barrier, potential energy profiles, applications of tunnelling, field emission, gate oxide tunnelling, hot electron effects in MOSFETs, coulomb blockade, blockade in nano capacitor, tunnel junctions, blockade in quantum dot circuits.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Quantum electronics and single electron transistor
- CO2:CNT and nanoelectronic devices
- CO3:CNT FETs
- CO4:Nanoelectronics with tunnelling devices
- CO5:Tunnel Junctions

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanoelectronic Circuit Design	Niraj K. Jha, Deming Chen	Springer	First Edition, 2010
2	Nano-Electronics and Quantum Computation	Shareefraza J. Ukkund	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-81812-9	First Edition, 2018
Reference Books				
3	Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices	Goser Karl, Peter Glosekotter	Springer	First Edition, 2004
4	Nanoscale Transistors: Device Physics, Modelling and	Lundstrom, Mark, Guo, Jing	Springer	First Edition, 2006
5	Current at the Nanoscale	Colm Durkan	Imperial College Press	First Edition, 2007

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Course Code	**18NT72**	CIE Marks	40
Teaching Hours/Week (L: T :P)	(4:0:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- To develop skills of the students in understanding the basics of Molecular Biology and Genetic engineering.
- To provide basic knowledge on replication. Transcription and Translation.
- To provide knowledge on methods of cloning, construction of DNA libraries and applications of rDNA technology.

Module-1

MOLECULAR GENETICS

DNA as genetic material, classical experiments – Hershey and chase; AveryMcLeod& McCarty. Bacterial conjugation, transduction and transformation, prokaryotic andeukaryotic genome organization.

Module-2

REPLICATION AND TRANSCRIPTION

Replication in prokaryotes and eukaryotes - D-loop and rolling circle mode of replication, replication of linear viral DNA. Transcription- initiation, elongation, termination, features of promoters and enhancers, transcription factors, inhibitors, post-transcriptional modification - RNA splicing, ribozyme, RNA editing.

Module-3

TRANSLATION

Elucidation of genetic code, Process of translation in prokaryotes and eukaryotes, posttranslational modifications, Suppressor mutations, Regulation of gene expression - Lac and Trp operons.

Module-4

RECOMBINANT DNA TECHNOLOGY

DNA cloning, vectors, restriction enzymes, Construction of cDNA and genomic libraries. Screening of libraries with probes – Northern, Southern and Western blotting. PCR- Principle, application and types. RAPD, Site Directed Mutagenesis. Restriction mapping.

Module-5

APPLICATIONS OF RECOMBINANT DNA TECHNOLOGY

Cloning in plants, transgenic and knockout animals. Recombinant cytokines and antibodies, vaccines, gene-therapy, stem cell therapy. In-vitro fertilization, embryo transfer technology. GMO detection, identification and quantification methods.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Understand molecular genetics
- CO2: Understand replication and transcription
- CO3: Understand translation
- CO4: Understand recombinant DNA technology
- CO5: Apply the knowledge of rDNA technology

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Principles Of Gene Manipulation, An Introduction To Genetic Engineering	Primrose SB & Twyman	Blackwell Science Publications	First Edition, 2006
2	Molecular Biology and Genetic Engineering	Dr. Prasad Puthiyillam	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-82325-3	First Edition, 2018
Reference Books				
3	Molecular Biology	David Friefelder	Narosa Publ. House	First Edition, 1999
4	Genetic Engineering Principles and Practice	Sandhya Mitra	Macmillan India Ltd publications	First Edition, 2008
5	Elements of biotechnology	P. K. Gupta	Rastogi publications	First Edition, 2004

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

MOSFETS AND DIGITAL CIRCUITS

Course Code	**18NT731**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Describe, Illustrate and Analyze MOS transistor theory, MOS VI characteristics, NMOS and PMOS transistor and CMOS technology
- Define and describe realization of digital circuits using CMOS technology
- Describe, Demonstrate, Analyze and Design of Mealy and Moore Models, Synchronous Sequential Circuits, State diagrams and Registers and Counters.

Module-1

MOSFETs

Field – Effect Transistors: Introduction, Construction and Characteristics of JFETs, Transfer Characteristics-Derivation, Applying Schokley's Equation, Depletion Type.

MOSFET: Basic Construction, Types of MOS, NMOS, PMOS, Basic Operation and Characteristics, VI Characteristics, Fabrication process of MOS transistors, N-well process, twin well process, SOI process.

MOSFET models: Small signal model, introduction to second order effects: body effect, channel length modulation, sub threshold conduction.

Module-2

CMOS TECHNOLOGY

CMOS inverters, voltage transfer characteristics, propagation delay, power dissipation equation, MOSFET scaling and its impact on current and power equation

MOS capacitance, MOS modelling, Spice Models

Realization of digital circuits using CMOS technology: NAND Gate, NOR Gate, CMOS transmission gates, Multiplexer, 2:1, 4:1, XOR gate, XNOR gate, Complex logic circuits, AOI gate, OAI gate.

Module-3

CMOS SEQUENTIAL CIRCUITS

1-bit Latch, SR latch, gated SR latch, D-latch, positive triggered latch, negative triggered latch, master-slave register, flip flop, edge triggered register, JK flip flop, Latch vs Registers

Timing Diagram: Timing definitions, setup time, hold time, clock to q delay, maximum clock frequency, mux based latch, CMOS Schmitt trigger, ring oscillator.

Module-4

REGISTERS AND COUNTERS

Registers: Introduction, Registers: Four Bit Latch, Shift Register, Serial In Serial Out Shift Register: Left-Shift Serial-In Serial-Out Register with D Flip-Flop, Serial-In Parallel-Out Shift Register, Parallel-In Serial-Out Shift Register: PISO Left-Shift Register, Ring Counter, Johnson Counter.

Counters: Introduction, Synchronous Counter, Modulus-4 Synchronus Up Counter, Modulus-4 Synchronus Down Counter, Modulus-4 Synchronus Up/Down Counter, Modulus-8 Synchronus Up Counter, Modulus-8 Synchronus Down Counter, Modulus-8 Synchronus Up/ Down Counter.

Module-5

FINITE STATE MACHINES

Introduction, Mealy machine, Moore machines, sequence detector, examples of sequence detector of 4 bit sequence, representing counters using FSM diagrams.

Course Outcomes: At the end of the course the student will be able to:

- CO1: Construction and working of MOSFETs
- CO2:CMOS technology and Realization of digital circuits using CMOS technology
- CO3:CMOS sequential circuits
- CO4:Registers and Counters

- CO5:Interpretation of performance characteristics of Mealy and Moore Models

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Digital Circuits and Design	D. P. Kothari, J. S Dhillon	Pearson	First Edition, 2016
2	MOSFETs and Digital Circuits	Naveen Kumar J. R., Prasad Puthiyillam	LAP-Lambert Academic Publishers, ISBN: 978-613-9-97275-3	First Edition, 2018
Reference Books				
3	Digital Principles and Design	Donald D. Givone	McGraw Hill	First Edition, 2016
4	Fundamentals of logic design	Charles H Roth, Jr	Cengage Learning	First Edition, 2016
5	Electronic Devices and Circuits	David A. Bell	Oxford University Press	First Edition, 2017

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

NANOTECHNOLOGY IN AGRICULTURE AND FOOD PROCESSING

Course Code	**18NT732**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To study the basic interaction of different molecules which are helpful in both food and agricultural activities
- To understand the importance of nanomaterials and devices in precision farming, advanced materials used in agriculture and food industries.

Module-1

INTERMOLECULAR INTERACTIONS AND SUPRAMOLECULAR STRUCTURES

Water - Hydrophobic and Hydrophilic Interactions - Dispersion Interaction - Electrostatic Interactions - Atoms and Small Molecules - Polymers, Particles, and Surfaces - Steric Interactions Involving Soluble Polymers - Depletion Aggregation of Particles by Non-adsorbing Polymers - Bridging Aggregation of Particles by Adsorbing Polymers - Stabilization of Dispersed Particles by Adsorbing Polymers - Polymer Brushes to Prevent Particle Aggregation and Particle Deposition at Surfaces - Plant Cells - Organized Self-Assembled Structures - Langmuir Layers - Lipid Bilayers - Solid-Supported Lipid Bilayers.

Module-2

NANOPARTICLES IN AGRICULTURAL AND FOOD DIAGNOSTICS

Enzyme Biosensors and Diagnostics - DNA-Based Biosensors and Diagnostics - Radiofrequency Identification-Integrated Nanosensor Networks: Detection and Response- Lateral Flow (Immuno)assay - Nucleic Acid Lateral Flow (Immuno)assay - Flow-Through (Immuno)assays - Antibody Microarrays - Surface Plasmon Resonance Spectroscopy.

Module-3

NANOTECHNOLOGY IN FOOD PRODUCTION

Food and New Ways of Food Production - Efficient Fractionation of Crops - Efficient Product Structuring - Optimizing Nutritional Values - Applications of Nanotechnology in Foods: Sensing, Packaging, Encapsulation, Engineering Food Ingredients to Improve Bioavailability - Nanocrystalline Food Ingredients - Nano- Emulsions - Nano-Engineered Protein Fibrils as Ingredient Building Blocks - Preparation of Food Matrices - Concerns about Using Nanotechnology in Food Production.

Module-4

NANOTECHNOLOGY IN FOOD PACKAGING

Crop improvement - Reasons to Package Food Products - Physical Properties of Packaging Materials - Strength - Barrier Properties Light Absorption – Structuring of Interior Surfaces - Antimicrobial Functionality - Visual Indicators – Quality Assessment - Food Safety Indication - Product Properties - Information and Communication Technology - Sensors - Radiofrequency Identification Technology - Risks - Consumer and Societal Acceptance.

Module-5

TOXICOLOGY OF NANOMATERIALS IN FOOD

Characterization of Engineered Nanomaterials: Unique Issues for Characterization of Engineered Nanomaterials for Food Applications - Safety Assessment of Oral- Exposure Engineered Nanomaterials for Food Application - Experimental Design Considerations for Toxicology Studies – Toxico-kinetics – ADME – Toxico-dynamics - In Vivo Toxicity - In Vitro Toxicity - Study Reliability.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Intermolecular interactions and supramolecular structures
- CO2: Nanoparticles in agriculture and food diagnostics
- CO3: Nanotechnology in food production

- CO4: Nanotechnology in food packaging
- CO5: Toxicology of nanomaterials in food

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanoparticle Assemblies and Superstructures	Nicholas A. Kotov	CRC	First Edition, 2006
2	Nanotechnologies in Food and Agriculture	Mahendra Rai, Caue Ribeiro, Luiz Mattoso, Nelson Duran	Springer	First Edition, 2015
Reference Books				
3	Nanotechnology in agriculture and food production	Jennifer Kuzma and Peter VerHage	Woodrow Wilson International	First Edition, 2006
4	Nanobiomaterials Handbook	Balaji Sitharaman	Taylor & Francis Group	First Edition, 2011
5	Food Processing, Management And Nanotechnology	Annish Chauhan	ISBN: 978 93 5056 796 8	First Edition, 2016

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

NANODEVICES AND APPLICATIONS

Course Code	**18NT733**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the fundamental concepts of nanosensors and devises.
- To understand the working and circuitry of nanosensors and devices.

Module-1

FUNDAMENTALS OF NANOSENSOR DEVICES

Micro and nano-sensors, biosensor. Thermal energy sensors: temperature sensors, heat sensors, electromagnetic sensors, electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetic sensors, Mechanical sensors, pressure sensors, gas and liquid flow sensors, position sensors, chemical sensors, optical and radiation sensors- gas sensor.

Module-2

NANO BASED INORGANIC SENSOR DEVICES

Density of states (DOS) – DOS of 3D, 2D, 1D and 0D materials, one dimensional gas sensors:- gas sensing with nanostructured thin films, absorption on surfaces, metal oxide modifications by additives, surface modifications, Nano optical sensors, nano mechanical sensors, plasmon resonance sensors with nano particles.

Module-3

NANOELECTROMECHANICAL SYSTEMS (NEMS)

Introduction- Nano machining of NEMS based upon electron beam lithography, Nano electromechanical systems fabrication, nano imprint lithography, polymeric nanofiber templates, focused ion beam doping wet chemical etching, stencil lithography and sacrificial etching, large scale intergration, future challenges.

Module-4

NANOPARTICLES FOR SENSORS AND CIRCUITRY, AND NANO-BIOLOGICAL SENSOR DEVICES

Photoinduced Electron Transport in DNA: Electronic Devices Based on DNA, Charge Transport, DNA-Based Nanoelectronics, Electrical Manipulation of DNA on Metal Surfaces, DNA-Gold nanoconjugates; Noninvasive Biosensors in Clinical Analysis. Applications of Biosensor-based instruments for the bioprocess industry. Application of Biosensors for environmental samples. Introduction to Biochips and their application to genomics. BIAcore, an optical Biosensor.

Module-5

NANOMATERIALS FOR SUPERCAPACITOR DEVICES

Super Capacitor - Electrochemical Double Layer, Pseudo, Hybrid, Asymmetric, Selection of Electrode Materials for ASCs, Anode - Carbon-Based Material (AC, CNTs, Graphene), Metal Oxides, Metal Nitrides, Cathode - Conducting Polymers, Metal Oxides (RuO_2, MnO_2, V_2O_5, $Ni(OH)_2$), Emerging 2D Supercapacitor Electrodes, Materials for Supercapacitor - Electrodes of Super Capacitor, EDLC, pseudocapacitance, hybrid capacitors; Electrolytes for Supercapacitors, Seperators, ASC Devices, Sandwich-Type (Carbon-Cloth-Material, Carbon Paper, Metal Scaffolds Configuration), Fiber-Type Supercapacitor Devices: Side-by-Side, Twist-Type, Coaxial-Helix Type, Wrap-Type; Applications of Supercapacitors.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Fundamentals of nanosensors devices
- CO2:Nano based inorganic sensor devices
- CO3:Nanoelectromechanical systems
- CO4:Nanoparticles for sensor and circuitry, and nano-biological sensor devices
- CO5:Nanomaterials for Supercapacitors

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanotechnology enabled sensors	KouroushKalantar – Zaheb, Benjamin Fry	Springer Verlag, New York	First Edition, 2007
2	Nanotechnology – Sensors and Devices	Dr. Prasad P., Dr. Savitha Prasad, Dr. Suryanarayana K	LAP-Lambert Academic Publishers. ISBN: 978-613-9-95331-8	First Edition, 2018
Reference Books				
3	Biosensing: International Research and Developments	Jerome Schults et al.	Spinger	First Edition, 2006
4	Sensors and signal conditioning	Ramon Pallas – Areny, John G. Webster John	Wiley & Sons	Second Edition, 2001
5	Nanoelectronics and Nanosystems	Karl Glosekotter	Springer	First Edition, 2004

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

FUNDAMENTALS OF THERMODYNAMICS

Course Code	**18NT741**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand various concepts and definitions of thermodynamics.
- Comprehend the I-law and II-law of thermodynamics.
- Acquire the knowledge of various types of gas cycles.

Module-1

FUNDAMENTAL CONCEPTS, WORK AND HEAT

Fundamental Concepts: Thermodynamics definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; intensive and extensive properties. Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and noncyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium. Zeroth law of thermodynamics.

Work and Heat: Mechanics-definition of work and its limitations. Thermodynamic definition of work. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Heat. Comparison between work and heat.(Note: Numerical problems are not included)

Module-2

FIRST LAW OF THERMODYNAMICS:

Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non – cyclic processes, energy, energy as a property, modes of energy, pure substance; definition, two-property rule, Specific heat at constant volume, enthalpy, specific heat at constant pressure. Extension of the First law to control volume; steady state-steady flow energy equation, important applications. (Note: Numerical problems are not included)

Module-3

SECOND LAW OF THERMODYNAMICS AND ENTROPY

Second Law of Thermodynamics:Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir. Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine, schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamics; Clausius statement of Second law of Thermodynamics, Equivalence of the two statements.Entropy: Clausius inequality; Statement, proof, application to a reversible cycle. Entropy; definition, a property, change of entropy, principle of increase in entropy.(Note: Numerical problems are not included)

Module-4

PURE SUBSTANCES, IDEAL GASES, THERMODYNAMIC RELATIONS

Pure Substances & Ideal Gases: Mixture of ideal gases and real gases, ideal gas equation, compressibility factor use of charts. P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, Saturated liquid, mixture of saturated liquid and vapour, saturated vapour and superheated vapour states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality). Thermodynamic relations: Maxwells equations, Tds relations, evaluation of thermodynamic properties from an equation of state.(Note: Numerical problems are not included)

Module-5

GAS CYCLES

Efficiency of air standard cycles, Carnot, Otto, Diesel cycles, P-V & T-S diagram, calculation of efficiency;

Carnot vapour power cycle, simple Rankine cycle, Analysis and performance of Rankine Cycle, Ideal and practical regenerative Rankine cycles – Reheat and Regenerative Cycles, Binary vapour cycle.
(Note: Numerical problems are not included)

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Fundamental concepts of thermodynamics, work and heat
- CO2: First law of thermodynamics
- CO3: Second law of thermodynamics and entropy
- CO4: Pure substances, ideal gases, thermodynamic relations
- CO5: Gas cycles

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Basic and Applied Thermodynamics	P K Nag	Tata McGraw Hill Pub	Second Edition, 2002
2	Basic Engineering Thermodynamics	A Venkatesh	Universities Press, India	First Edition, 2007
Reference Books				
3	Thermodynamics: An Engineering Approach	Yunus A. Cenegal, Michael A.	TataMcGraw Hill publications	First Edition, 2002
4	Engineering Thermodynamics	J. B. Jones, G. A. Hawkins	John Wiley and Sons	First Edition, 1986
5	Fundamentals of Classical Thermodynamics	G. J. Van Wylen, R. E.	Wiley Eastern	First Edition, 1985

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

GREEN NANOTECHNOLOGY

Course Code	**18NT742**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the eco-friendly nature of nanotechnology and the Nanomaterials.
- To study nanotechnology and nanodevices which are environmental friendly.

Module-1

GREEN MANUFACTURING TRENDS

Green Manufacturing - Fundamentals and Applications - basic definitions and issues surrounding green manufacturing at the process, machine and system - government motivations for green manufacturing - traditional manufacturing to green manufacturing - economic issues surrounding green manufacturing – the areas of automotive - semiconductor and medical areas and also supply chain and packaging areas.

Module-2

SUSTAINABLE GREEN MANUFACTURING

Green manufacturing sustainability - processes - requirements, and risk – The sustainable lean and green audit process - International green manufacturing standards and compliance - Green rapid prototyping and rapid manufacturing - Green flexible automation - Green collaboration processes - Alternative energy resources - Sustainable green manufacturing system design.

Module-3

WASTE MANAGEMENT

Sustainability and global conditions - Material and solid waste management - Energy management -chemical waste management and green chemistry – Climate change and air emissions management - Supply water and waste water management - Environmental business management.

Module-4

INDUSTRIAL ECOLOGY

Introduction - Material flows in chemical manufacturing - Industrial parks - Assessing opportunities for waste exchanges and by product synergies – Life cycle concepts - Product stewardship and green engineering - Regulatory, social and business environment for green manufacturing - Metrics and analytical tools - Green supply chains - Present state of green manufacturing.

Module-5

GREEN PLASTICS MANUFACTURING

Introduction to commercial plastics and elastomers - Natural Rubber (NR), modified NR and blends - Polyesters from microbial and plant biofactories (polylactic acid and poly hyroxyalkanoates) -Plastics from vegetable oils – Cellulose and starch based materials - Natural fillers, fibres, reinforcements and clay nanocomposites - Biodegradability, life cycle assessment and economics of using natural materials.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Green manufacturing trends
- CO2: Sustainable green manufacturing
- CO3: Waste management
- CO4: Industrial ecology
- CO5: Green plastic manufacturing

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Green engineering	David Allen T., David R. Shonnard	Prentice Hall NJ	First Edition, 2002
2	Green manufacturing fundamental and applications	David Dornfeld	Prentice hall	First Edition, 2002
Reference Books				
3	Green electronics design and manufacturing	Sammy Shinga G	Prince Publications	First Edition, 2008
4	Green chemistry	James Clark	Blackwell publishing	First Edition,
5	Sustainable manufacturing	Paulo Davim	Wiley publications	First Edition,

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

NANOTECHNOLOGY IN BIOMEDICAL ENGINEERING

Course Code	**18NT743**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To learn the basic importance and applications of Nanotechnology medical and biological fields.
- To understand techniques and design the nanostructures, nanodevices, nano-based diagnostics techniques, therapeutics, and devices as implants, drug delivery devices.

Module-1

INTRODUCTION

Synthesis of nanomaterials by Physical, Chemical and Biological methods. Popular Characterization methods. Carbon nanotube and its bio-applications. DNA Nanotechnology, Protein and Glyco-Nanotechnology, Lipid Nanotechnology. Nanotoxicology.

Module-2

IMPACT OF NANOTECHNOLOGY ON SURGERY

Introduction, Surgical blades and suture needles. Nanoshell particles, minimally invasive surgery using catheters, optical tweezers. Bio-molecular motors, Nanorobotics, gold and silver nanoparticles for cancer therapy, chemotherapy, Immunotherapy, Vaccine immunotherapy, Radiotherapy, thermotherapy, photo dynamic therapy.

Module-3

SENSING APPLICATIONS

Nanoprobes as BioPhotonics. Diagnostic Biosensors. Functionalized Metallic Nanoparticles and their Applications in Colorimetric Sensing, Dip stick Tests. Nanochip for HIV detection. Nanoparticles in Magnetic Resonance Imaging- Optical nanoparticles sensors for quantitative intracellular imaging. Cancer imaging-Nanophotonics.

Module-4

NANO-ARTIFICIAL CELLS AND BIONANOMACHINES

Nano-materials in bone substitutes & Dentistry, Natural nanocomposite systems as spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Implantable materials for vascular interventions, active implantable devices and bionics, Implantable materials for orthopaedic and dentistry. Wound care products. Polymeric nanofibres.

Module-5

NANOPARTICLES IN DRUG DELIVERY DEVICES

Sustained and targeted drug delivery, delivery mechanism – Introduction, antibody conjugated nanoparticles and their interactions with biological surfaces, Biomedical nanoparticles – Liposomes, dendrimers, Nanoscale drug delivery devices, Nano vectors for gene therapy, mechanism of drug targeting, drug delivery carriers, Nanoparticulate delivery systems, nano-particle mediated drug delivery to solid tumors, colloidal nanosilver particles as an effective nano antibiotic.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: DNA nanotechnology
- CO2: Impact of nanotechnology in surgery
- CO3: Sensing applications
- CO4: Nano-artificial cells and bionanomachines
- CO5: Nanoparticles in drug delivery devices

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Biomedical Nanotechnology	Malsch, N.H.	CRC Press	First Edition,
2	Nanotechnology in Biomedical Engineering	Abhinaya Nellerichale	LAP-Lambert Academic Publishing,Mauritius. ISBN: 978-613-9-83115-9	First Edition, 2018
Reference Books				
3	Nanobiotechnology II: More Concepts and Applications	Mirkin, C.A., Niemeyer, C.M.	Wiley-VCH	First Edition, 2007
4	Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications,	Kumar, C. S. S. R., Hormes, J., Leuschner C.	WILEY -VCH Verlag GmbH & Co	First Edition, 2005
5	The Handbook of Nanomedicine	K. K. Jain	Humana press	First Edition, 2008

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

OPEN ELECTIVE - B

APPLICATIONSOF NANOTECHNOLOGY IN ELECTRONICS

Course Code	**18NT751**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the basics of nanotechnology and its perspective in electrical and electronics industry
- To comprehend and investigate role of nanotechnology in energy production, storage, distribution and conversion
- To study and review nanotechnology trends in telecommunication industry

Module-1

ENERGY PRODUCTION, ENERGY STORAGE AND DISTRIBUTION

Nanotechnology and Applications for Electric Power: The Perspective of a Major Player in Electricity, Lightweight Nanostructured Materials and Their Certification for Wind Energy Applications, Carbon Nanotube Wires and Cables: Near-Term Applications and Future Perspectives, Carbon Nanotube Materials to Realize High-Performance Supercapacitors.

Module-2

ENERGY CONVERSION AND HARVESTING, NANOENABLED MATERIALS

Nanostructured Thermoelectric Materials: Current Research and Future Challenges. Energy Consumption in Information and Communication Technology: Role of Semiconductor Nanotechnology, Nanocrystalline Bainitic Steels for Industrial Applications, Graphene and Graphene Oxide for Energy Storage, Impact of Nanotechnology on Telecommunications, Nanotubes and Their Applications in Telecommunications, Quantum Dot Cellular Automata: The Prospective Technology for Digital Telecommunication Systems.

Module-3

FUNDAMENTALS OF NANOSENSOR DEVICES

Micro and nano-sensors, biosensor. Thermal energy sensors: temperature sensors, heat sensors, electromagnetic sensors, electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetic sensors, chemical sensors, optical and radiation sensors- gas sensor.

Module-4

NANOELECTROMECHANICAL SYSTEMS (NEMS)

Introduction- Nano machining of NEMS based upon electron beam lithography, Nano electromechanical systems fabrication, nano imprint lithography, polymeric nanofiber templates, focused ion beam doping wet chemical etching, stencil lithography and sacrificial etching, large scale intergration, future challenges, applications.

Module-5

CNT AND NANOELECTRONIC DEVICES

Introduction to Nano devices: Graphene transistors, Nanowire FET, quantum Dot devices, Quantum Dot FET, Organic transistors, CNTFET, FinFETs.

CARBON NANOTUBE FETS

Introduction, Single Wall Nano Tube (SWNT), Double Wall Nano Tube (DWCNT), design of inverter using CNTFET, CNTFET based digital and analog circuits, memory cell using CNTFET.

Course Outcomes: At the end of the course the student will be able to:

- Understand the fundamentals of nanotechnology and importance of nanotechnology in electrical and electronics industry.
- Evaluate and determine the standards, technological challenges and future trends of nanotechnology in electronics and electrical engineering.
- Initiate, innovate and develop nanotechnology-based solutions in the field of electronics and electrical

engineering.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanotechnology for Energy Sustainability	Baldev Raj, Marcel Van de Voorde, Yashwant Mahajan	Wiley-VCH Verlag GmbH & Co. KGaA	First Edition, 2017
2	Nanotechnology for Telecommunications	Sohail Anwar, M. Yasin Akhtar Raja, Salahuddin Qazi,	CRC Press	First Edition, 2017
Reference Books				
3	Nanodevices and Applications	Prasad Puthiyillam	LAP-Lambert Academic Publishers, Mauritius.	First Edition, 2018
4	Nano-Electronics and Quantum Computation	Shareefraza J. Ukkund	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-81812-9	First Edition, 2018
5	The Wonder of Nanotechnology: Quantum Optoelectronic Devices and Applications	Manijeh Razeghi; Leo Esaki; Klaus von Klitzing	SPIE PRESS BOOK	First Edition, 2013

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

OPEN ELECTIVE - B

NANO-TRIBOLOGY AND FRACTURE MECHANICS

Course Code	**18NT752**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To understand the applications of nano technology in mechanical engineering &the mechanics of nanomaterials.
- To understand the concept of nano tribology & fracture mechanics and advancement in nano materials.

Module-1

NANOTECHNOLOGY IN MECHANICAL ENGINEERING

Introduction, importance of nanotechnology in mechanical engineering, Basic concepts in nano technology. Mechanical Properties of nano materials: Importance of nano materials in various mechanical aspects. Nano composites-Significance, advantages. Nano Composites for sustainable, performance enhancing mechanical members. Categorized application of nano materials, role of nano-structured materials in mechanical engineering applications.

Module-2

INTRODUCTION TO NANO MECHANICS

Materials, films coatings, industrial considerations, structures & geometries. Mechanical behaviour of nano particles: Elasticity and plastic deformation mechanisms, Hardness & Strength, Creep of Nano crystalline materials. Defects and testing of nano structures. Different failure mechanism of Nano materials- elastic degradation failure mode-Stiffness modulus of nano composites-case studies, microstructure changes, electro chemical degradation, physical degradation.

Module-3

INTRODUCTION TO NANOTRIBOLOGY, NANOMATERIALS CHARACTERIZATION

Definition of Nanotribology, need of nano tribology,Understand nano tribology. Introduction to Atomic Force Microscope (AFM),surface force apparatus (SFA) and FFM to understand Nano tribology. Measurement of Surface roughness, friction force, Scratching, wear and machining, Surface potential measurements, Nano indentation measurements, Boundary lubrication measurements, selection of low friction and better adhesion for nanotechnology applications, Present Applications of nanotribology.

Module-4

FRACTURE OF NANO MATERIALS

Nano indentation method to evaluate toughness for thin films-understanding fracture toughness-methods, fracture mechanism of brittle thin films, fracture of mono & multi layers of gold nano particles,hollow silica nano particles,fracture mechanism of solid lubricant nanoparticles,fracture mode of ultrasonic treated nickel nano particles.

Module-5

ADVANCED NANO MATERIALS

Block Copolymer Systems-Introduction, Self-Assembly of Block Copolymers, Precursors for Novel Composite Materials –Introduction, CNT–Metal based nano particle Composites, CNT–AuNP Composite. Nano ceramics-Applications, Carbon Nano tubes Adsorbents for purification purpose, Nano material Imprinting Technique, Fullerene contained Nanostructures, Combined CNT with Bio molecules: Advancements and future Challenges.

Course Outcomes: At the end of the course the student will be able to:

- Applications of nano materials in mechanical engineering,
- Understand Mechanics of nano materials
- Understand nano-tribology
- Understand Failure modes in nanostructures
- Advancements in nanomaterials

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Advanced Analytical Methods in Tribology	Martin Dienwiebel, Maria-Isabel De Barros Bouchet	Springer	First Edition, 2018
2	Nanotribology and Nanomechanics: An Introduction	Bharat Bhushan	Springer	Fourth Edition, 2017
Reference Books				
3	Principles And Applications Of Tribology	Bharat Bhushan	Wiley-Blackwell publications	First Edition, 2013
4	Understanding Nanomaterials	Malkiat S. Johal, Lewis E.	Textbook Series in Physical Sciences	First Edition, 2018
5	Fundamentals of Engineering Tribology with Applications	Harish Hirani	Wiley	First Edition, 2016

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

OPEN ELECTIVE - B

NANOMATERIALS FOR CONSTRUCTION AND ENVIRONMENTAL APPLICATIONS

Course Code	**18NT753**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To learn the importance of nanotechnology in Civil Engineering.
- To understand how nanomaterials can be used in construction materials.
- To understand the latest development nanotechnology for civil and environmental engineering application.

Module-1

INTRODUCTION: Introduction to Nanoscience and Technology, basic principles and important Concept of Nanotechnology, Nanomaterial, Nano size effect, Surface area, Surface to volume ratio, Property of Nanomaterials- Mechanical, Electrical, optical, Thermal, Magnetic and Catalytic. Awareness and Existing activities of nanotechnology relevant to construction - desk study. Understanding phenomena of traditional construction materials at nanoscale.

Module-2

NANOTECHNOLOGY IN CONSTRUCTION MATERIALS: Nanomaterials in Concrete and Cement, Introduction, different nanomaterials used in concrete, Development of nano concrete, Application of nanomaterials in UHPC, Nano silica, densification of cement using Nanosilica, Nano alumina, Carbon nanotube (CNT), the Effect of SWCNT and Other Nanomaterials on Cement Hydration and Reinforcement, Polycarboxylates, Titanium oxide, Nano kaolin, Nano clay. Nanomaterials-Enabled Multifunctional Concrete and Structures, Next-Generation Nano-based Concrete Construction Products: Optimization of Clay Addition for the Enhancement of Pozzolanic Reaction in Nano-modified Cement Paste.

Module-3

NANOTECHNOLOGY IN STRUCTURAL MATERIAL: Nanotechnology and Steel, Applications in steel structures, for strength, corrosion resistance, improving strength of steel with nanomaterials, effect of copper nanoparticles of strength of steel. MMFX steel and application. Applications in welds and joints, weld ability, delayed fracture, strengthening of steel bolts, vanadium and molybdenum nanoparticles to improve delayed fracture.Wood as structural material, nanomaterials to improve the structural performance and serviceability of wood, nanocomposites, polymer -nanocomposite.

Module-4

NANOTECHNOLOGY AND COATINGS: Nanomaterials based paints, insulating Properties nanomaterials, Smart nanomaterials for building and Glass, Nanomaterials for Thermal or Fire Retarding, Functional coatings and thin films. Environment and performance monitoring sensors and devices. Nano sensors for structural health monitoring.

Advances in instrumentation, Atomic force microscopy, Nano indentation techniques, Neutron and X-ray scattering techniques for construction materials.

Module-5

NANOTECHNOLOGY IN ENVIRONMENTAL ENGINEERING: Introduction, nanomaterials for clean water, waste water treatment, Nanomaterials as adsorbent for removal of pollutant, microorganisms, heavy metals. Removal of pesticides and fungicides with Nanomaterials. Nanomaterials for water disinfection, Nanofiltration. Nanomaterials as photo catalyst, catalyst. Nanomaterials for capturing CO_2. Nanomaterials for Air pollution remediation, Air purification and Emission mitigation using Nanomaterials. Nanotechnology for detection of pollutant in air and water, Nano sensors and application. Environmental risk due to Nanomaterials, Nanotoxicology.

Course Outcomes: At the end of the course the student will be able to:

- CO1: To learn the basic concepts of Nanotechnology.
- CO2:To understand nanomaterial properties useful in construction materials
- CO3:Able to understand nanotechnology application in civil engineering
- CO4:Use nanomaterials in Environmental engineering

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanoscience and Nanotechnology: fundamentals to Frontiers	M.S. Ramachandra Rao, Shubra Singh	Wiley	First Edition, 2013
2	Nanostructures and Nanomaterials synthesis, properties and	G Cao	Imperial College press	First Edition, 2004
Reference Books				
3	Environmental Application Of Nanotechnology	G.A. Mansoori, T. Rohani. Bastami, A. Ahmadpour, Z., Eshaghi	Annual Review of Nano Research	First Edition, 2008
4	Environmental Application and Risks of Nanotechnology	JieZhuang and Randall W. Gentry	ACS Symposium Series; American Chemical Society: Washington, DC	First Edition, 2011
5	Nanotechnology in Construction	Sobolev, Konstantin, Shah, Surendra P.	Springer,	First Edition, 2015

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

MOLECULAR BIOLOGY AND GENETIC ENGINEERING LAB

Course Code	**18NTL76**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(0:0:2)	SEE Marks	60
Credits	01	Exam Hours	03

Course Learning Objectives:

- To understand the cell structure and organization of cell components.
- To isolate the genetic materials like DNA and RNA from different microbes, plants and also learn molecular biology techniques.

Sl. No.	Experiments
1	Study of divisional stages in Mitosis.
2	Study of divisional stages in Meiosis.
3	Study of slides of human cells
4	Study of Polytene and Lampbrush chromosomes using permanent slides
5	Isolation of genomic DNA from onion
6	Isolation of plasmid DNA from *bacteria*
7	Isolation of genomic DNA from banana
8	Agarose gel electrophoresis and quantification of nucleic acids (colorimetric, ethidium bromide dot blot
9	Isolation of RNA from yeast
10	Study of conjugation in *E.coli*
11	Amplification of DNA by PCR
12	Preparation of DNA for PCR applications- Isolation, purity & quantification

Course Outcomes: At the end of the course the student will be able to:

- Students can able to understand organization and different components at molecular scale level.
- Students can also learn different techniques used for the isolation of the genetic materials like DNA and RNA.
- Students can also learn the most advanced techniques like PCR, Gel Electrophoresis which are important techniques of molecular biology.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VII

PROJECT WORK PHASE - 1

Course Code	**18NTP77**	CIE Marks	100
Teaching Hours/Week (L: T: P)	(0:0:2)	SEE Marks	--
Credits	02	Exam Hours/Batch	--

Course Learning Objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas. ■

Project Work Phase - II: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course Outcomes: At the end of the course the student will be able to:

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it. ■

CIE procedure for Project Work Phase - 1:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work phase -1, shall be based on the evaluation of project work phase -1 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable.

The CIE marks awarded for the project work phase -1, shall be based on the evaluation of project work phase -1 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.■

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VIII

BIO-NANOTECHNOLOGY

Course Code	**18NT81**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To learn the basics of Nanobiotechnology, the devices of Nanobiotechnology and their applications to the different fields.
- To understand and fabricate the nanostructures and nano containers for several applications.

Module-1

FUNCTIONAL PRINCIPLES OF BIO-NANOTECHNOLOGY

Basic terms; Features and functions of DNA, RNA, and Artificial nucleic acids; Bio-nanotechnology and nano-biotechnology; Information driven nano-assembly: genetic information transfer, construction of proteins, storage of information; Energetics: approaches for powering chemical reactions, light dependent and independent reactions, electron carriers, storage of energy; Chemical transformations: reduction of entropy, chemical stabilization, specialized chemical tools; Biomaterials: introduction, biomineralization, biocompatibility and biopolymers, use of biomaterials; Self-replication; Machine-phase bio-nanotechnology.

Module-2

STRUCTURAL PRINCIPLES OF BIO-NANOTECHNOLOGY

Introduction; Natural bio-nanomachinery and specific environment; Strategies of construction of nanomachines: sequential covalent synthesis, covalent polymerization, self-organizing synthesis, and self-assembly; Biomolecular structure and stability: covalent bonds, dispersion and repulsion forces, hydrogen bonds, electrostatic interactions, and hydrophobic effects; Protein folding: Introduction, globular proteins, chaperons, stability, rigidity and disorder; Self-assembly: design principles, point group symmetries (cyclic, dihedral, and cubic), translational symmetry (line symmetry, plane symmetry, and space group symmetry), quasi-symmetry, crowded conditions; Self organization: introduction, self-organization of lipids; Molecular recognition: introduction, Crane principles. Flexibility and design of bio-nanomachines.

Module-3

BIO-NANOMACHINES

Introduction; Nanoscale effect on gravity, inertia, atomic granularity, thermal motion; Bionanomachies and water environment; Modern biomaterials and molecular plans: proteins (glycine and proline; carbon rich amino acids; phenylalanine, tyrosine, tryptophan; serine, threonine, histidine, aspargine, glutamine; cysteine, methionine), nucleic acids, polysaccharides, and lipids; Evolution of bio-nanomachines; Bio-nanomachines: Thymidylate synthase, DNA, Ribosome, ATP synthase, Actin and Myosin, Opsin, Triskelion molecules, and Collagen.

Module-4

BIOMEDICAL APPLICATIONS

Medical diagnostics: targeted and sustained drug delivery; Transdermal drug release; Nanoscale device for drug delivery; Nano-medicine and nano-surgery: Respirocytes and Microbivores, Surgical nanorobotics, nanorobotics advantages and disadvantages; Nanobased therapy of cancer; nanopathology; nanosurgery; Applications of DNA based bionanotechnology; Biosensors: antibodies, detection of glucose level, detection of specific DNA sequences; Medical imaging techniques: MRI, Ultrasound imaging.

Module-5

BIO-NANOTECHNOLOGY: TODAY AND THE FUTURE

Basic capabilities: simplification of natural proteins, design of proteins, construction of protein with non-natural amino acids, peptide nucleic acids; Nanomedicine: computer aided drug design, immunotoxins, Liposomes as vesicles, Artificial blood, Gene therapy, personalized medicine; Biomolecular sensing: smell and taste, light, motion, chemical gradients; A Timetable for bionanotechnology; Lessons for Molecular

Nanotechnology; Case Studies: Nanotube synthesis, A general nanoscale assembler, Nanosurveillance.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Functional principles of bio-nanotechnology
- CO2:Structural principles of bio-nanotechnology
- CO3:Bio-nanomachines
- CO4:Biomedical applications
- CO5:On-going Research in Bio-nanotechnology

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Bionanotechnology - Global Prospects	David E. Reisner	Taylor & Francis Group, LLC	First Edition, 2009
2	Applications of Bio-Nanotechnology	Dr. Prasad P. Embrandiri	LAP-Lambert Academic Publishing, Mauritius. ISBN: 978-613-9-81794-8	First Edition, 2018
Reference Books				
3	Bio-Applications of Nanoparticles	BY Warren C.W. Chan	Springer Science, Business Media	First Edition, 2007
4	Nanobiotechnology: concepts, applications & perspectives	C.M. Niemeyer, C.A. Mirkin	Wiley-VCH	First Edition, 2012
5	Nanobiotechnology in Molecular Diagnostics: Current Techniques and Applications	K. K. Jain	Taylor & Francis, ISBN 9781904933175	First Edition, 2005

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VIII

DIGITAL SYSTEMS DESIGN

Course Code	**18NT821**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To design sub systems using combinational circuits and sequential circuits
- To design digital systems using CMOS logic and understand the physical structure of digital systems in its transistor schematic form
- To learn Verilog HDL programming and model digital systems using high level language

Module-1

FUNDAMENTALS OF DIGITAL SYSTEMS:
Combinational circuits, sequential circuits, basic gates, realization of logic using NAND, NOR and 2:1 Multiplexers, design of half adder, full adders, full subtractor, 1-bit comparator, decoders and encoders. Introduction to Verilog HDL, coding types, behavioural, structural and data flow, modelling of basic gates, half adder and full adder using Verilog HDL.

Module-2

DESIGNING WITH COMBINATIONAL CIRCUITS:
4-bit Ripple carry adder, 4-bit carry look ahead adder, 4-bit carry select adder, 4-bit comparator using 2-bit comparator, seven segment display controllers using encoders and decoders, parity generators and 3-bit shifters/rotators using multiplexers, barrel shifter/rotator using 2:1 multiplexer. Writing Verilog code for 4-bit ripple carry adder, parity generators.

Module-3

DESIGNING WITH SEQUENTIAL CIRCUITS:
SR latch, SR-D Latch, T-Latch, flip flops using positive triggered and negative triggered latch, designing N-bit synchronous and asynchronous counters, up-down counters, designing clock dividers using counters, shift registers, SISO, SIPO, PISO, PIPO, 1-bit memory unit with read and write enable, 4-bit memory unit with address decoder.

Module-4

DIGITAL CIRCUIT DESIGN USING MOS TRANSISTOR:
MOS transistor, NMOS and PMOS transistor, CMOS inverter circuit, CMOS circuit design for NAND, NOR, AND, OR, XOR, XNOR gate, transmission gate using CMOS, 2:1 multiplexer design using CMOS transmission gate, 1-bit latch using CMOS (2:1 multiplexer), 1-bit flip flop using CMOS latch. Introduction to propagation delay, rise time, fall time, noise margin for CMOS inverter. Introduction to power dissipation in CMOS circuits, dynamic power, static power, leakage power.

Module-5

SUBSYSTEM DESIGN AND MODELLING:
writing Verilog code using data flow description for D-latch, JK-flip flop, counters, 2-Bit Magnitude comparators, 4x4 memory with read and write ports, behavioural model for 4-bit ALU design using Verilog HDL, writing test bench wave forms for functional verification of 4-bit adders and ALU. Introduction to programmable logics such as PLA, PAL and FPGAs.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Fundamental of digital systems
- CO2:Design of sub systems using combinational circuits
- CO3:Design of sub systems using sequential circuits
- CO4:Digital circuit design using MOS transistor

- CO5:Apply the Verilog programming skills in modelling digital sub systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	HDL programing fundamental: VHDL and Verilog	N. Botros	Cengage learning	First Edition, 2007
2	Digital Fundamentals	Thomas L. Floyd	Pearson Publications	First Edition, 2012
Reference Books				
3	CMOS VLSI Design: A circuit and systems perspective	Neil H. E. Weste, David Money Harris	Pearson Education	Third Edition, 2010
4	Fundamentals of Digital Logic Design with Verilog Design	Stephen Brown, ZvonkoVranesic	Tata McGraw Hill Edition	First Edition, 2015
5	Digital Design Principles and Practices	John F. Wakerly	Prentice Hall of India	First Edition, 2014

.

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VIII

NANO TOXICOLOGY

Course Code	**18NT822**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To learn the basic importance and regulations of nanotoxicology in biological fields.
- To understand toxicity produced by nanostructures and methods to reduce their toxicity.

Module-1

INTRODUCTION

Concept of Nanotoxicology - Inhalation of nanomaterials– overview. Introduction Inhalation – deposition and pulmonary clearance of insoluble solids- bio– persistence of Inhaled solid material. Systemic translocation of inhaled particles. Nano particle exposure and systematic cardiovascular effects – experimental data–respiratory particulate matter exposure and cardiovascular toxicity, nanoparticles–hypothesis and research approaches - Ecotoxicologic studies – Methodology - for Nanotoxicology - toxicity testing.

Module-2

NANOMATERIAL POLLUTION, PUBLIC PERCEPTIONS, AND EDUCATION

Nanomaterials pollution: Nanomaterials in Environment - Toxicology of Airborne – Effect of Nanomaterials in the environment. Safety and pollution Control techniques-handling, storage, packaging, transportation and disposal.

Public perceptions & education: Communicating Nanotechnological Risks - Understanding of Nanotechnology's Social Impacts - Nanotechnology in the Media. Educating Undergraduate Nanoengineers,

Module-3

HUMAN EXPOSURE TO NANOSIZED MATERIALS

Biological Activities of Nanomaterials and Nanoparticles - Respiratory Tract – Efficient deposition of inhaled NSPs. - Disposition of NSPs in the respiratory - Disposition of NSPs in the respiratory -Epithelial translocation - Translocation to the circulatory system - Neuronal uptake and translocation -Translocation of NSPs in the blood circulation to bone marrow in mice - Studies of neuronal translocation of UFPs from respiratory tract - Exposure via GI Tract and Skin.

Module-4

ECONOMIC IMPACTS OF NANOTECHNOLOGY

Socio-Economic Impact of Nanoscale Science - Managing the Nanotechnology Revolution: Consider the Malcolm - Transcending Moore's Law with Molecular Electronics and Nanotechnology - Semiconductor Scaling as a Model for Nanotechnology Commercialization - Nanotechnology and Zettabits - Sustaining the Impact of Nanotechnology - Non-Nano Effects of Nanotechnology on the Economy.

Module-5

ETHICS LAWS AND REGULATIONS

Ethical Issues in Nanoscience and Nanotechnology - Ethics & Law in a New Frontier– An Exploration of Patent Matters Associated with Nanotechnology - The Ethics of Ethics- Negotiations over Quality of Life in the Nanotechnology Initiative. Patenting nanotechnology, nanomedicine and nanopharmaceuticals.

Course Outcomes: At the end of the course the student will be able to:

- CO1: To learn the basic concepts of nanobiotoxicology.
- CO2: To understand nanomaterial pollution, public perceptions & education
- CO3: To study the human exposure to nanosized materials
- CO4: To do risk economic impacts of nanotechnology
- CO5: To study ethics laws and regulations of nanomaterials and their toxicity

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Nanotoxicology: Interactions of Nanomaterials with Biological Systems	Yuliang Zhao and Hari Singh Nalwa	American Scientific Publishers	First Edition, 2018
2	Nano Toxicology	Abhinaya Nellerichale, Apoorva B. Udupa, Prasad Puthiyillam	LAP-Lambert Academic Publishers. 978-613-9-95619-7	First Edition, 2018
Reference Books				
3	Human Physiology: The Mechanisms of Body. Functions	E P. Widmaier, H. Raff, K.T. Strang, Vander, Sherman and Luciano	McGraw Hill, New York	Nineth Edition, 2004
4	Nanotoxicology: Characterization, Dosing and Health Effects	Monteiro-Riv	Informa Healthcare publishers	First Edition, 2007
5	Nanotechnology in health care	P.D. Gupta, N. Udupa.	S.P. Publications, India	First Edition, 2011

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VIII

MICROCONTROLLERS AND INTERFACE

Course Code	**18NT823**	CIE Marks	40
Teaching Hours/Week (L: T: P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To study basic principles of micro-controllers family.
- To understand designing and interfacing the devices with micro controllers.

Module-1

MICROPROCESSORS AND MICROCONTROLLER

Introduction, Microprocessors and Microcontrollers, RISC & CISC CPU Architectures, Harvard & Von-Neumann CPU architecture, Computer software. The 8051 Architecture: Introduction, Architecture of 8051, Pin diagram of 8051, Memory organization, External Memory interfacing, stacks.

Module-2

ADDRESSING MODES AND INSTRUCTION SET

Introduction, Instruction syntax, Data types, Subroutines, addressing modes: Immediate addressing, Register addressing, Direct addressing, Indirect addressing, relative addressing, Absolute addressing, Long addressing, Indexed addressing, Bit inherent addressing, bit direct addressing. Data transfer instructions, Arithmetic instructions

Module-3

8051 INSTRUCTION SET

Instruction timings, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction.

INTERFACING

Interfacing stepper motor – program to rotate stepper motor, interfacing DC motor – program to control the speed of DC motor, interfacing serial A/D converter, interfacing D/A converter using parallel ports – program to generate square wave by interfacing DAC08 with parallel port.

Module-4

MICROCONTROLLER PIC16F84

Introduction, CISC, RISC, Applications, Clock/instruction cycle, Pipelining, Pin description, Clock generator – oscillator, Reset, Central processing unit, Ports, Memory organization, Interrupts, Free timer TMR0, EEPROM Data memory.

PIC16CXX INSTRUCTION SET

Introduction to instruction set in pic16cxx microcontroller family, data transfer, arithmetic and logic, bit operations, directing the program flow, instruction execution period.

Module-5

OVERVIEW OF THE AVR FAMILY

History, AVR feature's, AVR family overview – classic AVR – Mega AVR – Tiny AVR – Special purpose AVR.

AVR ARCHITECTURE

The general-purpose registers in the AVR, AVR data memory, instructions with the data memory, AVR status register, AVR data format and directives.

Course Outcomes: At the end of the course the student will be able to understand:

- CO1: Microprocessors and microcontrollers
- CO2: Addressing modes
- CO3: 8051 Instruction set, interfacing
- CO4: Microcontroller PIC 16F84, PIC16CXX Instruction Set
- CO5: Overview of AVR family, AVR architecture

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	8051 microcontroller : Hardware, software and applications	V Udayashankara, M, Mallikarjunasw	McGraw Hill	First Edition, 2017
2	PIC microcontrollers	Nebojsa Matic	mikroElektronik a	First Edition, 2003
Reference Books				
3	The AVR microcontroller and embedded system: Using Assembly and C	Muhammad Ali Mazidi, Sarmad NaimiSepehrNa imi	Pearson New International Edition	First Edition, 2010
4	The 8051 Microcontroller and Embedded Systems	Mazidi, Mazidi, McKinlay	Pearson New International Edition	Second Edition, 2014
5	The 8051 Microcontroller	Kenneth Ayala	Thomson International Publishers	Third Edition, 2015

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VIII

PROJECT WORK PHASE -II

Course Code	**18NTP83**	CIE Marks	40
Contact Hours/Week	02	SEE Marks	60
Credits	08	Exam Hours/Batch	03

Course Learning Objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - II: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course Outcomes: At the end of the course the student will be able to:

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.■

CIE procedure for Project Work Phase - 2:

(i)Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.■

Semester End Examination

SEE marks for the project (60 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) as per the University norms by the examiners appointed VTU.

B. E. NANO TECHNOLOGY (NT)
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER -VIII

TECHNICAL SEMINAR

Course Code	**18NTS84**	CIE Marks	100
Contact Hours/Week	02	SEE Marks	--
Credits	01	Exam Hours	--

Course Learning Objectives:

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Each student, under the guidance of a Faculty, shall choose, preferably, a recent topic of his/her interest relevant to the Course of Specialization.

- Carryout literature survey organize the seminar content in a systematic manner.
- Prepare the report with own sentences, avoiding cut and paste act.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the

Course Outcomes: At the end of the course the student will be able to:

- Attain, use and develop knowledge in the field of engineering and other disciplines through independent learning and collaborative study.
- Identify, understand and discuss current, real-time issues.
- Improve oral and written communication skills.
- Explore an appreciation of the self in relation to its larger diverse social and academic contexts.
- Apply principles of ethics and respect in interaction with others.■

Evaluation Procedure:

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three teachers from the department with the senior most acting as the Chairman.

Marks distribution for CIE of the course:

Seminar Report: 50 marks

Presentation skill: 25 marks

Question and Answer: 25 marks. ■