VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Semester: III

ENGINEERING MATHEMATICS III [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. Semester: III			
Subject Code	17MAT31	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			
(Common to all B.E. branches)			

BASICS OF MATERIAL SCIENCE [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: III			
Subject Code	17NT32	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

Course 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.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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,	10	L1, L2

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.	10	L1, L2, L3
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.	10	L1, L2, L3
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;	10	L1, L2, L3

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.	10	L1, L2, L3, L4

Course outcome:
On completion of this course, students will be able to:

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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. D. John Thiruvadigal, S. Ponnusamy, C. Preferencial Kala, M. Krishna Mohan, "Material Science" Vibrant Publications, 2014
2. Fundamentals of Material Science, Prasad Puthiyillam, Savitha Prasad, Narayana Hebbar, LAP-Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-3-659-93009-6
3. Callister's "Materials Science and Engineering" Adapted by R, Balasubramaniam, Wiley India Pvt. Ltd, New Delhi, 2011
4. Dr. M. K. Muralidhara, "Material Science and Metallurgy", Subhas Stores, 2011

REFERENCE BOOKS:

1. Donald Askeland, Pradeep Fulay, Wendelin Wright, The Science & Engineering of Materials, 6th Ed., Cengage Learning, 2011
2. Raghavan V. "Materials Science & Engineering – A First Course", 5th edition, Prentice Hall of India, New Delhi, 2005
3. Thiruvadigal, J. D., Ponnusamy, S. and Vasuhi.P. S., "Materials Science", 5th edition, Vibrant Publications, Chennai, 2007

FOUNDATIONS OF NANOSCALE SCIENCE AND TECHNOLOGY
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: III

Subject Code	17NT33	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
Module 2 **CLASSIFICATION OF NANOSTRUCTURES**	10	L1, L2

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.	10	L1, L2, L3
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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3, L4
Course outcome: On completion of this course, students will be able to: • Describe fundamentals of nanoscience and nanotechnology; • Classify nano-structures; • Develop smart materials; • Analyse biomaterials; • Explain nanotoxicology		
Graduate Attributes (as per NBA): o Engineering Knowledge. o Problem Analysis. o Design / development of solutions (partly). o Interpretation of data.		

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Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Edward L. Wolf, "Nanophysics and Nanotechnology - An Introduction to Modern Concepts in Nanoscience" Second Edition, John Wiley & Sons, 2006.
2. Foundations of Nanoscale Science and Technology,Shareefraza J. Ukkund, Prasad Puthiyillam, LAP-Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-613-958649-3
Nanotechnology – Basic Science & Emerging Technologies: 2002 by Michael Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, and Burkhard Raguse.
3. Nanoparticles technology: Masuo Hosokawa, Kiyoshi Nogi, Makio Naito, Toyokazu Yokoyama, First edition 2007, ISBN: 978-0-444-53122-3.

REFERENCE BOOKS:

1. Vladimir P. Torchilin (2006) Nanoparticulates as Drug Carriers, Imperial College Press.
2. M. Reza Mozafari (2007) Nanomaterials and Nanosystems for Biomedical Applications.
3. K.W. Kolasinski, "Surface Science: Foundations of Catalysis and Nanoscience", Wiley, 2002.
4. Biomimetics: lessons from nature – an overview by Bharath bhushan
5. Biomimetics—using nature to inspire human innovation Yoseph Bar-Cohen.

MOSFETs AND DIGITAL CIRCUITS

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: III

Subject Code	17NT34	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

Course objectives:
This course will enable students to:

- 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.

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Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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	10	L1, L2
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.	10	L1, L2
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	10	L1,L2, L3
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.	10	L1, L2, L3, L4
Module 5 **FINITE STATE MACHINES**	10	L1, L2, L3, L4

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

Course outcome:
After studying this course, students will be able to understand:

- Construction and working of MOSFETs
- CMOS technology and Realization of digital circuits using CMOS technology
- CMOS sequential circuits
- Registers and Counters
- Interpretation of performance characteristics of Mealy and Moore Models

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. D. P. Kothari and J. S Dhillon, "Digital Circuits and Design", Pearson, 2016, ISBN: 9789332543539.

REFERENCE BOOKS:

1. Donald D. Givone, "Digital Principles and Design", McGraw Hill.
2. Charles H Roth, Jr., "Fundamentals of logic design", Cengage Learning.
3. David A. Bell, "Electronic Devices and Circuits", Oxford University Press.

PHYSICAL AND CHEMICAL PRINCIPLES OF NANOTECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: III

Subject Code	17NT35	IA Marks	40
Number of Lecture Hours/Week	03	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:
To learn the physical and chemical principles involved in the materials and systems.

		Revised

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Modules	Teaching Hours	Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
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 illustration.	10	L1, L2
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.	10	L1,L2, L3
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.	10	L1, L2, L3
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,	10	L1, L2, L3

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 outcome:
After studying this course, students will be able to understand:

- Basics of quantum mechanics
- Basics of thermodynamics
- Concepts of lattice vibrations and band theory of solids
- Semiconductors and tunnelling
- Principles and applications of colloidal systems

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Solid State Physics: S.O. Pillai
2. A text book of engineering chemistry, Shashi Chawla, Dhanpat Rai & Co, Educational and Technical Publishers, Delhi, 2011

REFERENCE BOOKS:

1. Thermodynamics and Statistical Mechanics by John M. Seddon, J. D. Gale
2. Introduction to Solid State Physics C. Kittle
3.Solid State Physics: A.J. Decker

FUNDAMENTALS OF BIOSCIENCE
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: III

Subject Code	17NT36	IA Marks	40
Number of Lecture	03	Exam Marks	60

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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Choice Based Credit System (CBCS)
B.E. Nano Technology

Hours/Week			
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 03

Course objectives:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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.	08	L1, L2, L3
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.	08	L1,L2, L3
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.	08	L1, L2, L3
Module 5 **BIOMACHINES** Biomotors: Conversion of Chemical Energy into Mechanical	08	L1, L2, L3, L4

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 outcome:
After studying this course, students will be able to understand:

- Basics of cell biology
- Concepts of biological membranes
- Fundamentals of molecular biology
- Basics of immunology
- Concepts and applications of biomachines

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Microbiology by Michael J Pelczar Jr Chan ECS, Noel R Krieg, Tata McGraw Hill Publishing co Ltd.
2. Fundamentals of Bioscience, Abhinaya Nellerichale, Aprrova B. Udupa, Dr. Prasad Puthiyillam, LAP-Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-613-9-82263-8
3. 'Biochemistry'J.M.Berg, J.L.Tymosczko and L.Sryer. W.H. Freeman Publications.
4. 'Molecular Motors', Frank H. Deis, Nancy Counts Gerber, Roger E. Koeppe, II.

REFERENCE BOOKS:

1. Principles of protein structure. G. Schuiz and R.H. Shrimer, SpringerVerlag, 1984.
2. Principles of Nucleic acid structure.W. Saenger,Springer 1984.
3. Physical Chemistry of Membranes:An introduction to the structure and dynamics of biological membranes. B.L. Siler,Allen and Unwin and the Solomon Press, 1985.

SIMULATION AND MODELLING LAB

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
SEMESTER – III

Laboratory Code	17NTL37	IA Marks	40

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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Number of Lecture Hours/Week	01Hr Instructions + 02 Hr Laboratory	Exam Marks	60
		Exam Hours	03
CREDITS – 02			

Course 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

Laboratory Experiments:	Revised Bloom's Taxonomy (RBT) Level
Evaluate using MATLAB: (a) $\frac{1}{2\times3}$ (b) $2^{2\times4}$ (c) $5 \times 10^{-4} + 2.5 \times 10^{-2}$	L1, L2, L3
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].	L1, L2, L3
Consider the given function $f(x) = \frac{x}{1+x^2}, \quad -2 \le x \le 2$ Write a Matlab code to plot with the elements of its vector representation	L5, L6
Consider the following linear system: 2x1 + 2 x2=18 -x1 + 2 x2=2 solve the system using the graphical method with MATLAB	L5, L6
Let $A = \begin{bmatrix} 1.2969 & .8648 \\ .2161 & .1441 \end{bmatrix}$ (a) Find the determinant and inverse of A (using Matlab). (b) Let B be the matrix obtained from A by rounding off to three decimal places (1.2969 7→ 1.297). Find the determinant and inverse of B. How do A−1 and B−1 differ? Explain how this happened. (c) Set b1 = [1.2969; 0.2161] and do x = A \ b1 . Repeat the process but with a vector b2 obtained from b1 by rounding off to three decimal places. Explain exactly what happened. Why was the first answer so simple? Why do the two answers differ by so much?	L5, L6
Write a well-commented function program for the function $x^2 e^{-x2}$, using entry-wise operations (such as .* and .^). To get e^x use exp(x). Include adequate comments in the program. Plot the function on [−5, 5]. Turn in printouts of the program and the graph.	L5, L6
Write a well-commented script program that graphs the functions sin x, sin 2x, sin 3x, sin 4x, sin 5x and sin 6x on the interval [0, 2π] on one plot. (π is pi	L5, L6

in Matlab.) Include comments in the program. Turn in the program and the graph.	
Suppose a ball is dropped from a height of 2 meters onto a hard surface and the coefficient of restitution of the collision is .9 (see Wikipedia for an explanation). Write a well-commented script program to calculate the total distance the ball has traveled when it hits the surface for the n-th time. Enter: format long. By trial and error approximate how large n must be so that total distance stops changing. Turn in the program and a brief summary of the results.	L5, L6
(a) Write a well-commented Matlab function program *myinvcheck* that a. makes a n × n random matrix (normally distributed, A = randn(n,n)), • b. calculates its inverse (B = inv(A)), • c. multiplies the two back together, • d. calculates the residual (difference from the desired n × n identity matrix eye(n)), and • e. returns the norm of the residual. (b) Write a well-commented Matlab script program that calls *myinvcheck* for n = 10, 20, 40, . . . , 2 i10 for some moderate i, records the results of each trial, and plots the error versus n using a log plot. (See help loglog.) What happens to error as n gets big? Turn in a printout of the programs, the plot, and a very brief report on the results of your experiments.	L1, L2, L3
You are given the following data: > t = [0 .1 .499 .5 .6 1.0 1.4 1.5 1.899 1.9 2.0] > y = [0 .06 .17 .19 .21 .26 .29 .29 .30 .31 .31] (a) Plot the data, using "*" at the data points, then try a polynomial fit of the correct degree to interpolate this number of data points: What do you observe. Give an explanation of this error, in particular why is the term badly conditioned used? (b) Plot the data along with a spline interpolant. How does this compare with the plot above? What is a way to make the plot better?	L5, L6
Course Outcome: • 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.	
Graduate Attributes (as per NBA) • Engineering Knowledge. • Problem Analysis. • Design/Development of solutions.	
Conduct of Practical Examination: 1. All laboratory experiments are to be included for practical examination. 2. Students are allowed to pick one experiment from the lot. 3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks. 4.Change of experiment is allowed only once and 15% Marks allotted to the procedure part	

to be made zero.
Reference Book 1. Introduction to Numerical Methods and Matlab Programming for Engineers, Todd Young and Martin J. Mohlenkamp, May 5, 2015 2. MATLAB for Engineering Applications, ABDULLAH ALSHEHRI

DIGITAL ELECTRONICS LAB

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
SEMESTER – III

Laboratory Code	17NTL38	IA Marks	40
Number of Lecture Hours/Week	01Hr Instructions+ 02 Hr Laboratory	Exam Marks	60
		Exam Hours	03

CREDITS – 02

Course 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.

Laboratory Experiments: **NOTE:** Use discrete components to test and verify the logic gates. Multisim may be used for designing the gates along with the above.	**Revised Bloom's Taxonomy (RBT) Level**
1. To verify (a) Demorgan's Theorem for 2 variables (b) The sum-of product and product-of-sum expressions using universal gates.	**L1, L2, L3**
2. To design and implement (a) Full Adder using basic logic gates. (b) Full subtractor using basic logic gates.	**L5, L6**
3. To design and implement 4-bit Parallel Adder/ subtractor using IC 7483.	**L5, L6**
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	**L2, L3**
5. To realise the following flip-flops using NAND Gates. (a) Clocked SR Flip-Flop (b) JK Flip-Flop	**L2, L3**
6. To realize the following shift registers using IC7474 (a) SISO (b) SIPO (c)PISO (d) PIPO	**L2, L3**

7. To realize the Ring Counter and Johnson Counter using IC7476	L2, L3
8. To realize the Mod-N Counter using IC7490	L2, L3
9. To Interface 8051 to a toggle Switch and 8 LEDs to light up LEDs alternatively when the Switch is ON (in Assembly language).	L4, L5, L6
10. To Interface 8051 to LCD to display a message (in C Language).	L4, L5, L6
11. To Interface 8051 to Stepper Motor to rotate the motor for a given number of steps (C language programming).	L4, L5, L6
12. Interface a Light dependant resistor (LDR), a relay and buzzer to make a light operated switch (in Assembly language).	L4, L5, L6

Course outcomes:
On the completion of this laboratory course, the students 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.

Graduate Attributes (as per NBA)

- Engineering Knowledge.
- Problem Analysis.
- Design/Development of solutions.

Conduct of Practical Examination:
1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4.Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Reference Book
(For 1 to 6 experiments):
1. K. A. Navas, "Electronics Lab Manual", Volume I, PHI, 5th Edition, 2015, ISBN:9788120351424.
(For 9 to 12 experiments):
2. Cyril Prasanna Raj P., "CMOS digital circuit design manual", Volume 1, MSEC E-publication, Edition 2016

KANNADA
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E.
Semester: IV

Subject Code	17KL39	IA Marks	20
Number of Lecture Hours/Week	01	Exam Marks	30
Total Number of Lecture Hours		Exam Hours	01

CREDITS – 01
(Common to all B.E. branches)

CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND HUMAN RIGHTS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. Semester: IV			
Subject Code	17CPH39	IA Marks	20
Number of Lecture Hours/Week	01	Exam Marks	30
Total Number of Lecture Hours		Exam Hours	01
CREDITS – 01			
(Common to all B.E. branches)			

Semester: IV

ENGINEERING MATHEMATICS IV [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. Semester: IV			
Subject Code	17MAT41	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			
(Common to all B.E. branches)			

MATERIALS SCIENCE AND ENGINEERING [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: IV			
Subject Code	17NT42	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60

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Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course 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.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
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.	10	L1, L2
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	10	L1,L2, L3

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	10	L1, L2, L3
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, thermoresponsive 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.	10	L1, L2, L3, L4

Course outcome:
On completion of this course students will be able to:

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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:
1. Donald R. Askeland, Pradeep P. Fulay, D. K. Bhattacharya, Materials Science and Engineering, Second Indian Reprint, Cengage Learning, 2010
2. Callister's "Materials Science and Engineering" Adapted by R, Balasubramaniam, Wiley India Pvt. Ltd, New Delhi, 2011
3. Dr. M. K. Muralidhara, "Material Science and Metallurgy", Subhas Stores, 2011

REFERENCE BOOKS:
1. D. John Thiruvadigal, S. Ponnusamy, C. Preferencial Kala, M. Krishna Mohan, "Material Science" Vibrant Publications, 2014
2. Raghavan V. "Materials Science & Engineering – A First Course", 5th edition, Prentice Hall of India, New Delhi, 2005
3. Thiruvadigal, J. D., Ponnusamy, S. and Vasuhi.P. S., "Materials Science", 5th edition, Vibrant Publications, Chennai, 2007
4. A text book of engineering chemistry, Shashi Chawla, Dhanpat Rai and Co, 2011

SYNTHESIS AND PROCESSING TECHNIQUES
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: IV

Subject Code	17NT43	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
Module 2 **CHEMICAL METHODS 1:**	10	L1, L2, L3

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.	10	L1,L2, L3
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 inmicroorganisms; Use of microorganisms for nanostructure formation, Role of plants in nanoparticle synthesis, synthesis of nanoparticles using proteins and DNA templates.	10	L1, L2, L3, L4
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.	10	L1, L2, L3, L4
Course outcome: On completion of this course, students should be able to: • Experiment physical techniques used for synthesis and processing of nanomaterials; • Analyse chemical methods used for synthesis and processing of nanomaterials; • Understand spray pyrolysis methods and fundamentals of VLS • Select biological methods used for synthesis and processing of nanomaterials; • Test surface modifications of nanoparticels.		
Graduate Attributes (as per NBA): o Engineering Knowledge. o Design / development of solutions (partly).		
Question paper pattern: • The question paper will have ten questions.		

- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Hari Singh Nalwa - Encyclopedia of Nanotechnology.
2. Synthesis and Processing Techniques, Naveen Kumar Jagadapura Ramegowda, Shareefraza J. Ukkund, Prasad Puthiyillam, LAP Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-613-9-81532-6
3. Chemistry of Nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
4. Nanochemistry: A chemical approach to NanomaterialsRoayal Society of Chemistry, Ozin and Arsenault, Cambridge UK 2005,

REFERENCE BOOKS:

1. Nanomaterials – A. K. Bandyopadhyay, New Age International Publishers, 2nd Edition, 2010
2. T. Pradeep, "NANO The Essential, understanding Nanoscience and Nanotechnology". Tata McGrawHill Publishing Company Limited, 2007.
3. Shareefraza J. Ukkund, Prasad Puthiyillam, Foundations of Nanoscale Science and Technology, LAP-Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-613-958649-3
4. David G. Bucknall. Nanolithography and patterning techniques in microelectronics, CRC Press

ELECTRONIC INSTRUMENTS AND MEASUREMENTS

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: IV

Subject Code	17NT44	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives:
In this course students will learn about:

- 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.

Modules	Teaching Hours	Revised Bloom's Taxonomy

		(RBT) Level
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	10	L1, L2
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.	10	L1, L2
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.	10	L1,L2, L3
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.	10	L1, L2, L3, L4
Module 5 **TRANSDUCERS, AND ACTUATORS**	10	L1, L2, L3

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

Course outcomes:
After studying this course, students will be able to:

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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. A. D. Helfrick and W.D. Cooper, "Modern Electronic Instrumentation and Measuring Techniques", Pearson, 1st Edition, 2015, ISBN:9789332556065.
2. H. S. Kalsi, "Electronic Instrumentation", McGraw Hill, 3rd Edition, 2012, ISBN:9760070702066.

REFERENCE BOOKS:

1. A. K. Sawhney, "Electronics and Electrical Measurements", Dhanpat Rai & Sons.
2. David A. Bell, "Electronic Instrumentation and Measurements", Oxford University Press.

APPLICATIONS OF NANOTECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: IV

Subject Code	17NT45	IA Marks	40
Number of Lecture Hours/Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDITS – 04			

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2, L3
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.	10	L1, L2, L3
Module – 3 **NT IN AGRICULTURE, AND FOOD PROCESSING APPLICATIONS** **NT in agriculture applications:** Overview of nanotechnology	10	L1,L2, L3

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, Radiation shielding (Thermal protection), Space elevator, Space elevator (electromagnetic).	10	L1, L2, L3
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.	10	L1, L2, L3
Course outcome: After completion of this subject, students will be able to: • Describe applications of nano technology in the photovoltaics, batteries, and fuel cells; • Illustrate nano technology in the energy transmissions, water purification, and defense; • Explain nano technology in the agriculture and food processing; • Describe nano technology in the civil engineering, automobile, and aerospace sector;		

- Research nano technological advances in the electronics, computer engineering, and photonics.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Nanotechnology, Importance & Applications, M.H. Fulekar, I.K. International Publishing House, New Delhi, 2011
2. Applications of Nanotechnology, Prasad Puthiyillam, LAP Lambert Academic Publishing, Mauritius, 2018, ISBN: 978-613-9-58532-8
3. Nanotechnology, Fundamentals and Applications, Manasi Karkare, I.K. International Publishing, New Delhi, 2008, ISBN : 978-81-89866-99-0

REFERENCES:

1. "How helpful is nanotechnology in agriculture?-Review", Allah Ditta, Advances in natural sciences: Nanoscience and nanotechnology, 3 (2012) 033002 (10pp), IOP Publishing, doi:10.1088/2043-6262/3/3/033002
2. Nanotechnology – Innovation opportunities for tomorrow's defense, Frank Simonis and Steven S, Freely downloadable from web.
3. Nanotechnologies in Automobiles-Innovation potentials in Hesse for the Automotive industry and its subcontractors, Volume 3 of the Aktionslinie, Hesse Nanotech series of publications. 2008
4. Nanotechnology for green building, George Elvin, Green Technology Forum, 2007

BIOCHEMISTRY AND MICROBIOLOGY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: IV

Subject Code	17NT46	IA Marks	40
Number of Lecture Hours/Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDITS – 03			

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Course objectives:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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.	08	L1, L2, L3, L4
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.	08	L1,L2, L3
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.	08	L1, L2, L3
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.	08	L3, L4, L5

Course outcome:
After completion of this subject, students will be able to:

- Understand biomolecules and biological membranes

- Fundamental principles of bioenergetics and metabolism
- Basics of microbiology
- Understand microbiological growth and control of microorganisms
- Understand apply the knowledge of microbial synthesis of nanomaterials

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:
- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Microbiology by Michael J Pelczar Jr Chan ECS, Noel R Krieg, Tata McGraw Hill Publishing co Ltd.
2. Biochemistry and Microbiology, Shareefraza J. Ukkund, Abhinaya Nellerichale, Dr. Prasad Puthiyillam, LAB-Lambert Academic Publishing, Mauritius, 2018, ISBN: 978-613-9-83272-9.
3. Lehninger- Principles of Biochemistry by David L. Nelson and Michael M. Cox, 5th Edition,WH Freeman and Company.
4. Principles of Biochemistry by LubertStryer, Freeman Int. Edition

REFERENCE BOOKS:

1. T. Pradeep, “NANO The Essential, understanding Nanoscience and Nanotechnology”. Tata McGraw - Hill Publishing Company Limited, 2007.
2. C. A. Mirkin and C. M. Niemeyer, Nanobiotechnology- II, More Concepts and Applications, WILEY-VCH, VerlagGmbH&Co, 2007

ELECTRONIC INSTRUMENTATION LAB

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
SEMESTER - IV

Laboratory Code	17NTL47	IA Marks	40
Number of Lecture Hours/Week	01HrInstructions + 02 Hr Laboratory	Exam Marks	60
		Exam Hours	03

CREDITS – 02

Course 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

Laboratory Experiments:	Revised Bloom's Taxonomy (RBT) Level
1. To find the value of unknown resistor using Wheatstone bridge.	L1, L2, L3
2. To find the value of unknown capacitance and inductance using Maxwell's bridge	L4, L5, L6
3. To find the value of unknown capacitance using Wein's series and parallel bridge.	L5, L6
4. Measurement of frequency using Lissajous method	L4, L5, L6
5. To study and verify characteristic of variable resistor transducer (strain gauge)	L5, L6
6. To study and verify characteristic of LVDT	L5, L6
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	L5, L6
8. Measurement of pressure using piezoelectric pick up.	L5, L6
9. To interface temperature sensor to Data Acquisition Kit and display the temperature measured.	L1, L2, L3
10. Study of distance measurement using ultrasonic transducer.	L5, L6
11. Measurement of power and energy using ARDUINO	L5, L6

Course Outcome:
- 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

Graduate Attributes (as per NBA)
- Engineering Knowledge.
- Problem Analysis.
- Design/Development of solutions.

Conduct of Practical Examination:
1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4.Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Reference Book
1. Lab Manual

BIOCHEMISTRY AND MICROBIOLOGY LAB

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
SEMESTER – IV

Laboratory Code	17NTL48	IA Marks	40
Number of Lecture Hours/Week	01Hr Instructions + 02 Hr Laboratory	Exam Marks	60
		Exam Hours	03

CREDITS – 02

Course 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, etc.

Lab experiments	Revised Bloom's Taxonomy (RBT) Level
1. Qualitative analysis of glucose	L1, L2, L3
2. Iso-electric precipitation of proteins; casein from milk	L4, L5
3. Qualitative analysis of fructose	L1, L2, L3
4. Separation of amino acids by thin layer chromatography	L5, L6
5. Estimation of saponification value of fats/oils	L5, L6
6. Detection of adulteration in milk	L5, L6
7. Qualitative analysis of amino acids	L5, L6
8. Estimation of iodine value of fat/oil	L5, L6
9. Titration curves of amino acids	L1, L2, L3
10. Estimation of blood glucose by glucose-oxidase method	L5, L6
11. Estimation of acid value from castor oil/coconut oil	L5, L6
12. Quantitative estimation of amino acids by ninhydrin method	L4, L5

Course Outcome:
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.

Graduate Attributes (as per NBA)
- Engineering Knowledge.
- Problem Analysis.

Design/Development of solutions.

Conduct of Practical Examination:
1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Reference Book
1. Lab Manual

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

KANNADA [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. Semester: IV			
Subject Code	17KL49	IA Marks	20
Number of Lecture Hours/Week	01	Exam Marks	30
Total Number of Lecture Hours		Exam Hours	01
CREDITS – 01			
(Common to all B.E. branches)			

CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND HUMAN RIGHTS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. Semester: IV			
Subject Code	17CPH49	IA Marks	20
Number of Lecture Hours/Week	01	Exam Marks	30
Total Number of Lecture Hours		Exam Hours	01
CREDITS – 01			
(Common to all B.E. branches)			

Semester: V

Core Subjects

MANAGEMENT AND ENTREPRENEURSHIP [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: V			
Subject Code	17NT51	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

CREDIT - 04		
Course Objective: • To learn various aspects and principles of Management, Planning, and Organization. • To learn the concepts of Entrepreneurship, and Project Management		
Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
Module 2: PLANNING: 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.	10	L1, L2, L3
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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Course Outcome: Students can learn about • Management • Planning • Organization • Entrepreneurship, and • Project Management
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. Principles of Management – P.C. Tripathi, P.N. Reddy – Tata McGraw Hill, 2007. 2. Dynamics of Entrepreneurial Development & Management – Vasant Desai:, Himalaya Publishing House, 2007. 3. Entrepreneurship Development – Poornima M Charantimath – Small Business Enterprises, Pearson Education, 2006.
REFERENCE BOOKS: 1. Management Fundamentals: Concepts, Application, Skill Development – Robert Lusier –, Thompson, 2007. 2. Entrepreneurship Development – S. S. Khanka, S. Chand & Co, 2007. 3. Management – Stephen Robbins: 17th Edition, Pearson Education / PHI, 2003.

SYNTHESIS OF NANO MATERIALS
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: V

Subject Code	17NT52	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT - 04			

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
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.	10	L1, L2, L3
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.	10	L1, L2, L3
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).	10	L1, L2, L3, L4

Advantages and drawbacks of nanoporous materials. Potential Uses of nanoporous materials.		
Module 5: BIOLOGICAL METHODS: Introduction, Advantages, disadvantages and applications of biological method, Use of bacteria, fungi, Actinomycetes for nanoparticles synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Green synthesis of nanoparticles, Synthesis by leaf extracts.	10	L1, L2

Course Outcome:
After completion of this subject, students will be able to understand and apply the knowledge of:

- Synthesis of metal oxides and semiconductors
- Synthesis of quantum dots and metal nanoparticles
- Synthesis of oxide and non-oxide nanoparticles
- Synthesis of nanoporous materials
- Biological synthesis of nanoparticles

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Guozhong Cao, “Nano structures and Nano materials, synthesis, properties and applications”, world scientific series in nano science and technology, Vol. 2, 2011.
2. C. N. R. Rao, A. Muller, A. K. Cheetham “The Chemistry of Nano materials: Synthesis, Properties and Applications” @ 2004 WILEY-VCH Verlag GmbH & Co. KgaA, Weinheim, ISBN 3-527-30686-2.
3. Synthesis of Nanomaterials,Shareefraza J. Ukkund, Smitha Rai, Prasad Puthiyillam, LAP-Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-613-9-82137-2
4. T. Pradeep, “NANO The Essential, understanding Nano science and Nanotechnology”. Tata McGraw-Hill Publishing Company Limited, 2007.

REFERENCE BOOKS:

1. Processing & properties of structural nano materials - Leon L. Shaw (editor)
2. C. A. Mirkin and C.M. Niemeyer, Nanobiotechnology- II, More Concepts and Applications, WILEY-VCH, VerlagGmbH&Co, 2007.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

CHARACTERIZATION TECHNIQUES [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: V			
Subject Code	17NT53	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT - 04			
Course Objective: To study the basic characterization tools and techniques To understand the structural, morphological, and surface composition of nanomaterials To understand the electrical measurement devices			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.		10	L1, L2
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		10	L1, L2, L3
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.		10	L1, L2, L3, L4
Module 4:		10	L1, L2, L3,

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.		L4
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.	10	L1, L2, L3

Course Outcome:
After completion of this subject, students will be able to understand and apply the knowledge of:

- Basics of characterization techniques
- X-ray based characterization
- Electron microscopy techniques
- Spectroscopic techniques
- Electrical measurements

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Characterization of Nanostructure materials by XZ.L.Wang
2. Nanomaterial Characterization, Naveen Kumar Jagadapura Ramegowda, Prasad Puthiyillam, LAP-Lambert Academic Publishing, Mauritius, 2018, ISBN: 978-3-330-34221-7
3. Instrumental Methods of Analysis, 7th edition- Willard, Merritt, Dean, Settle

REFERENCE BOOKS:

1. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition - Harold P. Klug, Leroy E. Alexander
2. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter
3. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton

DIGITAL SYSTEMS DESIGN

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: V

Subject Code	17NT54	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDIT - 04

Course Objective:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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	10	L1, L2, L3
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.	10	L1, L2, L3
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.	10	L1, L2, L3
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,	10	L1, L2, L3, L4

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	10	L1, L2, L3, L4

Course Outcome:

After successfully completing this course, students will be able to understand:

- Fundamental of digital systems
- Design of sub systems using combinational circuits
- Design of sub systems using sequential circuits
- Digital circuit design using MOS transistor
- Apply the Verilog programming skills in modelling digital sub systems

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

For Modules 1 – 3 & 5

1. N. Botros, HDL programing fundamental: VHDL and Verilog, Cengage learning, 2007
2. Thomas L. Floyd, Digital Fundamentals, Pearson Publications, 2012
3. John F. Wakerly, Digital Design Principles and Practices, Prentice Hall of India, 2014
4. Stephen Brown & Zvonko Vranesic, Fundamentals of Digital Logic Design with Verilog Design, Tata McGraw Hill Edition, 2015

For Module 4

1. Neil H. E. Weste & David Money Harris, CMOS VLSI Design: A circuit and systems perspective, 3rd edition, Pearson Education, 2010

REFERENCE BOOKS:

1. Leach D, Malvino A P, Saha G, Digital Principles and Applications, 8/e, McGraw Hill

Education, 2015.
2. Harris D. M. and, S. L. Harris, Digital Design and Computer Architecture, 2/e, Morgan Kaufmann Publishers, 2013

Professional Electives

ANALOG CIRCUIT DESIGN [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: V			
Subject Code	17NT551	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT - 03			

Course Objective:
4. To understand the concepts of analog circuits and design principles of analog circuits
5. To design and analyse working of CMOS based analog circuits and sub systems
6. To understand and design data converters using analog sub circuits

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: OPERATIONAL AMPLIFIER FUNDAMENTALS: Basic Op-amp circuit, Op-Amp parameters – Input and output voltage, CMRR and PSRR, offset voltages and currents, Input and output impedances, Slew rate and Frequency limitations. OP-Amps as DC Amplifiers – Biasing OP-amps, Direct coupled voltage followers, Non-inverting amplifiers, inverting amplifiers, Summing amplifiers, and Difference amplifiers.	08	L1, L2, L3
Module 2: ANALOG SUB CIRCUITS AND OSCILLATORS: Limiting circuits, Clamping circuits, Peak detectors, Sample and hold circuits, V to I and I to V converters, Differentiating Circuit, Integrator Circuit, Phase shift oscillator, Wein bridge oscillator, Crossing detectors, inverting Schmitt trigger. Log and antilog amplifiers, Multiplier and divider	08	L1, L2, L3
Module 3: INTRODUCTION TO ANALOG INTEGRATED CIRCUITS: MOS devices, small signal model, large signal model, MOS operation in linear, saturation and cut off regions, MOS inverters, bipolar junction transistor, small signal model, large signal model, MOS based current mirrors, types of current mirrors, current reference circuits, voltage reference circuits	08	L1, L2, L3, L4

Module 4: SINGLE STAGE AMPLIFIERS: MOS amplifier circuits, working principles of common source amplifier, common drain amplifier, common gate amplifier, differential amplifier, time domain response, frequency domain response, operational amplifier circuits, two stage amplifier and cascade amplifier, opamp comparators	08	L1, L2, L3, L4
Module 5: DATA CONVERTERS: Sampling and Quantization, sampling theorem, Nyquist rate sampling, Analog to digital converter, types of converters, working principles of flash ADC, SAR ADC, pipelined ADC, Sigma delta ADC, Digital to analog converters, resistor string converters, R-2R DAC, thermometric DAC, testing of data converters, low voltage data converter	08	L1, L2, L3, L4

Course Outcome:
After successfully completing this course, students will be able to:

- Understand the fundamental of analog circuit design and design of sub systems using opamps
- Use MOS transistors and design analog sub circuits such as single stage amplifiers and two stage amplifiers
- Build data converters using analog sub circuits and understand the design principles and working of data converters

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:
For Modules 1 & 2

2. David A. Bell, Operational Amplifiers and Linear ICs, 2nd edition, PHI/Pearson, 2004
3. Ramakant A Gayakwad, Op-Amps and Linear Integrated Circuits, Pearson, 4th Ed, 2015. ISBN 81-7808-501-1.

For Modules 3 to 5

4. David Johns and KENNETH M. MARTIN, Analog Integrated Circuit Design, John Wiley and Sons, 2013
5. B. Razavi, Design of Analog CMOS Integrated Circuits, 2nd edition, McGraw-Hill, 2017. ISBN 978-0-07-252493-2.

REFERENCE BOOKS:

1. D. Roy Choudhury and Shail B. Jain, Linear Integrated Circuits, 4th edition, Reprint 2006, New Age International ISBN 978-81-224-3098-1.
2. B Somanathan Nair, "Linear Integrated Circuits: Analysis, Design & Applications," Wiley India, 1st Edition, 2015.
3. Philips E. Allen, Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2012

BIOMATERIALS

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: V

Subject Code	17NT552	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT - 03

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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:	08	L1, L2, L3

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, Yttria stabilized zirconia, surface reactive ceramics, resorbable ceramics, composites, analysis of ceramic surfaces. Applications and Biocompatibility case studies of novel materials and alloys.	08	L1, L2, L3
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3, L4
Course Outcome: After successfully completing this course, students will be able to: 1. Understand the fundamental principals in material science and chemistry, and how they contribute to biomaterial development and performance. 2. Apply the science and engineering knowledge gained in the course to biomaterial selection and design for specific biomedical uses.		

3. Critically review papers from the scientific literature and identify areas of research opportunities
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. Biomaterials Science: An Introduction to materials in medicine by Buddy D Ratner. Academic Press. 2. Biomaterials - Temenoff and Mikos, Pearson Prentice Hall. 3. Polymeric Biomaterials by Severian Dumitriu. 4. Polymeric Biomaterials by Piskin and A S Hoffmann, Martinus Nijhoff
REFERENCE BOOKS: 1. Materials Science and Engineering: An Introduction – Callister, John Wiley and Sons. Science and Engineering of Materials - Askland and Phule, Thomson. 2. Material Science by Smith, McGraw Hill. 3. Material Science and Engineering by V Raghavan, Prentice Hall. 4. Biomaterials by Sujata V. Bhat, Narosa Publishing House. 5. Biomaterials, Medical Devices and Tissue Engineering: An Integrated Approach by Frederick H Silver, Chapman and Hall publications. 6. Advanced Catalysts and Nanostructures Materials, William R Moser, Academic Press.

FUNDAMENTALS OF THERMODYNAMICS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: V			
Subject Code	17NT553	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT - 03			
Course Objective:			

This course will enable students to
1. Understand various concepts and definitions of thermodynamics.
2. Comprehend the I-law and II-law of thermodynamics.
3. Acquire the knowledge of various types of gas cycles

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: FUNDAMENTAL CONCEPTS AND WORK & 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)	08	L1, L2
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)	08	L1, L2, L3
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.	08	L1, L2

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)	08	L1, L2, L3
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)	08	L1, L2, L3
Course Outcome: After studying this course, students will be able to: 1. Apply the concepts and definitions of thermodynamics. 2. Differentiate thermodynamic work and heat and apply I law and II law of thermodynamics to different process. 3. Apply the principles of various gas cycles		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module. • Numerical problems and not included.		
TEXT BOOKS: 1. A Venkatesh, “Basic Engineering Thermodynamics”, Universities Press, India, 2007, ISBN		

13: 9788173715877
2. P K Nag, "Basic and Applied Thermodynamics", 2nd Ed., Tata McGraw Hill Pub. 2002, ISBN 13: 9780070151314

REFERENCE BOOKS:
1. Yunus A. Cenegal and Michael A. Boles, "Thermodynamics: An Engineering Approach", TataMcGraw Hill publications, 2002, ISBN 13: 9780071072540
2. J. B. Jones and G. A. Hawkins, John Wiley and Sons, "Engineering Thermodynamics", Wiley 1986, ISBN 13: 9780471812029
3. G. J. Van Wylen and R. E. Sonntag, "Fundamentals of Classical Thermodynamics", Wiley Eastern, Wiley, 1985, ISBN 13: 9780471800149

NANOSTRUCTURES AND SELF-ASSEMBLY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: V

Subject Code	17NT554	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT - 03

Course Objective:
1. To understand the fundamental principals in Self-assembly of nanostructures, and how they contribute and control development of nanostructures by self-assembly.
2. To apply the science and engineering knowledge gained in the course to nanomaterial self-assemblies and design for specific applications.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: **INTRODUCTION:** Materials Self-Assembly, Molecular *vs.* Materials Self-Assembly, What is Hierarchical Assembly?, Directing Self-Assembly, Supramolecular Vision, Genealogy of Self-Assembling Materials, Learning from Biominerals - Form is Function, Two-Dimensional Assemblies, SAMs and Soft Lithography, Clever Clusters, Mesoscale Self-Assembly, Materials Self-Assembly of Integrated Systems, Layer-by-Layer Self-Assembly, Building One Layer at a Time, Electrostatic Superlattices, Organic Polyelectrolyte Multilayers, Layer-by-Layer Smart Windows, How Thick is Thin?, Assembling Metallopolymers, Polyelectrolyte-Colloid Multilayers, Graded	08	L1, L2

Composition LbL Films, LbL MEMS, Trapping Active Proteins, Layering on Curved Surfaces, Zeolite-Ordered Multicrystal Arrays, Crosslinked Crystal Arrays, Non-Electrostatic Layer-by-Layer Assembly		
Module 2: NANOROD, NANOTUBE, NANOWIRE SELF-ASSEMBLY: Introduction, Building Block Assembly, Templating Nanowires, Modulated Diameter Gold Nanorods, Modulated Composition Nanorods, Barcoded Nanorod Orthogonal Self-Assembly, Nanodisk Codes, Sir SERS, Self-Assembling Nanorods, Magnetic Nanorods Bunch Up, Magnetic Nanorods and Magnetic Nanoclusters, An Irresistible Attraction for Biomolecules, Hierarchically Ordered Nanorods, Nanorod Devices, Nanotubes from Nanoporous Templates, Layer-by-Layer Nanotubes from Nanorods. , Crossed Semiconductor Nanowires - Smallest LED, Nanowire Diodes and Transistors, Nanowire Sensors, Catalytic Nanowire Electronics.	08	L1, L2, L3
Module 3: NANOCLUSTER SELF-ASSEMBLY: Introduction, Building-Block Assembly, When is a Nanocrystal a Nanocluster or a Nanoparticle?, Synthesis of Capped Semiconductor Nanocrystals, Electrons and Holes in Nanocrystal Boxes, Nanocluster Phase Transformations, Watching Nanocrystals Grow, Nanocrystals in Nanobeakers, Capped Gold Nanocrystals - Nanonugget Rush, Alkanethiolate Capped Nanoclusters Diagnostics, Microporous and Mesoporous Materials from Soft Building Blocks, Escape from the Zeolite Prison, A Periodic Table of Materials Filled with Holes, Modular Self-Assembly of Microporous Materials, Hydrogen Storage Coordination Frameworks, Overview and Prospects of Microporous Materials, Mesoscale Soft Building Blocks, Micelle *vs.* Liquid Crystal Templating Paradox, Mesoporous Materials by Design, Tuning Length Scales, Mesostructure and Dimensionality, Mesocomposition - Nature of Precursors, Mesotexture, Periodic Mesoporous Silica-Polymer Hybrids	08	L1, L2, L3
Module 4: SELF-ASSEMBLING BLOCK COPOLYMERS: Introduction, Polymers, Polymers Everywhere in Nanochemistry, Block Copolymer Self-Assembly - Chip Off the Old Block, Nanostructured Ceramics, Nano-Objects, Block Copolymer Thin Films, Electrical Ordering, Spatial Confinement of Block Copolymers, Nanoepitaxy, Block Copolymer Lithography, Decorating Block Copolymers, A Case of Wettability, Nanowires from Block Copolymers, Making Micelles, Assembling Inorganic Polymers, Harnessing Rigid Rods, Supramolecular Assemblies, Supramolecular Mushrooms, Structural Color from Lightscale Block Copolymers, Block Copolypeptides, Block Copolymer Biofactories	08	L1, L2, L3, L4
Module 5: SELF-ASSEMBLY OF LARGE BUILDING BLOCKS: Introduction, Self-Assembling Supra-Micron Shapes, Synthesis Using	08	L3, L4, L5

the "Capillary Bond", Crystallizing Large Polyhedral-Shaped Building Blocks, Self-Assembling 2D and 3D Electrical Circuits and Devices, Crystallizing Micron-Sized Planar Building Blocks, Polyhedra with Patterned Faces That Autoconstruct, Large Sphere Building Block Self-Assemble into 3D Crystals, Synthetic MEMS?, Magnetic Self-Assembly, Dynamic Self-Assembly, Autonomous Self-Assembly, Self-Assembly and Synthetic Life		

Course Outcome:
After successfully completing this course, students will be able to:
1. Understand the fundamental principals in Self-assembly of nanostructures, and how they contribute and control development of nanostructures by self-assembly.
2. To apply the science and engineering knowledge gained in the course to nanomaterial self-assemblies and design for specific applications.
3. Critically review papers from the scientific literature and identify areas of research opportunities

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:
- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:
1. Nanochemistry - A Chemical Approach to Nanomaterials-Ozin, Geoffrey A.; Arsenault, André C.; Cademartiri, Ludovico-RSC publication
2. Self-Assembled Nanostructures- Jin Z. Zhang, Zhong-lin Wang, Jun Liu, Shaowei Chen, Gang-yu Liu-Springer
3. Design of Nanostructures: Self-Assembly of Nanomaterials-by Himadri B. Bohidar , Kamala Rawat-Wiley VCH

REFERENCE BOOKS:
1. Self-Assembly of Nanostructures, Vol. III, Editors: Bellucci, Stefano (Ed.)- The INFN Lectures Italy-Springer-2012
2. Self-Assembly and Nanotechnology: A Force Balance Approach, Yoon S. Lee, John Wiley & Sons, Inc., Hoboken, New Jersey.
3. Handbook of Self Assembled Semiconductor Nanostructures for Novel Devices in Photonics and Electronics-Edited by:Mohamed Henini, Publisher- Elsevier Ltd

Open Electives

INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Course: B.E. / Nano Technology Semester: V			
Subject Code	17NT561	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT - 03			

Course Objective:
To introduce the concept of nanoscience and nanotechnology.
To know the physics and chemistry concepts needed to understand the development of nanoscience and nanotechnology.
To learn about different nanomaterials and their applications.
To understand the importance and applications of nanotechnology.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: INTRODUCTION AND SCOPE Introduction to nanoscale, History, Evolution of various disciplines towards nanoscale focus, Plethora of potential applications, Recent achievements in nanotechnology, short-term commercial commercially viable nanotechnology products, specific applications, challenges and opportunities, technology scope, areas and sub-disciples, commercialization scope, present course of investigation.	08	L1, L2
Module 2: BASIC NANOTECHNOLOGY SCIENCE – PHYSICS Introduction, approach & scope, Key sub atomic particles, basic entities/particles of interest, basic physics terms of interest, scale of atomic entities, atomic distances and metaphors, elementary and non-elementary particles, key physical properties of elements, basic properties of silicon and basics of transistor operations: transistor, manufacturing approaches, manufacturing limitations.	08	L1, L2, L3
Module 3: BASIC NANOTECHNOLOGY SCIENCE – PHYSICS Introduction and background, basic chemistry concepts, physical aspects, key chemistry concepts, basic formulations/machinery of chemical reactions, chemistry of carbon, packing of atoms, ferro and antiferroelectrics, catalysts and sieves, super conductors, magnet.	08	L1, L2, L3
Module 4: NANOMATERIALS Introduction, basic nanostructures: CNTs, nanowires, nanocones; applications of nanotubes, wires & cones, quantum dots, quantum dot nanocrystals, ultananocrystalline diamond, diamondoids, nanocomposites, thin films, nanofoams, nanoclusters, smart	08	L1, L2, L3, L4

nanostructures, manufacturing techniques: general approaches & self-assembly methods, system design.		
Module 5: NANOTECHNOLOGY & ITS APPLICATIONS Introduction, materials used and applications in renewable energy generation, drug delivery, cosmetics, tissue engineering, bioinformatics, information technology, agriculture & food technology, high integrated circuits, nanomedicine, molecular motors, bioelectronics & spintronics.	08	L1, L2, L3, L4
Course Outcome: A useful subject to gain knowledge about evolution of nanoscience and nanotechnology, the physics and chemistry concepts needed to understand the development of nanoscience and nanotechnology, about different nanomaterials and their applications, and to understand the importance and applications of nanotechnology.		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
TEXT BOOKS: 1. Daniel Minoli, Nanotechnology applications to telecommunications and networking, John Wiley & Sons, 2013. 2. M. H. Fulekar, Nanotechnology importance and applications, I. K. International Publishing House Pvt. Ltd., New Delhi, 2013.		

NANOMATERIALS AND THEIR APPLICATIONS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: V			
Subject Code	17NT562	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT - 03			

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Course Objective:
To understand the importance of nanomaterials and their applications in
Electrical and electronics
Biomedical and pharmaceutics
Chemical industry
Food industry and Agriculture
Textile and Cosmetics

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: NANOMATERIALS FOR ELECTRICAL AND ELECTRONICS APPLICATIONS Advantages of nano electrical and electronic devices –Integrated Circuits – Lasers - Micro and NanoElectromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS –Diodes and Nano-wire Transistors -Data memory –Lighting and Displays – Organic electroluminescent displays – Quantum optical devices – Batteries - Fuel cells- Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products	08	L1, L2
Module 2: NANOMATERIALS FOR BIOMEDICAL AND PHARMACEUTICAL APPLICATIONS Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery – Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces –Protein Engineering – Drug delivery – Therapeutic applications	08	L1, L2, L3
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	08	L1, L2, L3
Module 4: APPLICATIONS OF NANOMATERIALS IN AGRICULTURE AND FOOD TECHNOLOGY Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology –Potential of nano-fertilizers – Nanotechnology in Food industry - Packaging, Food processing - Food safety and biosecurity – Contaminant detection – Smart packaging	08	L1, L2, L3, L4
Module 5:	08	L1, L2, L3,

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		L4

Course Outcome:
After completion of this course students will be able to identify and apply different nanomaterials for the following applications

- Electrical and electronics
- Biomedical and pharmaceutics
- Chemical industry
- Food industry and Agriculture
- Textile and Cosmetics

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Bharat Bhushan, “Handbook of Nanotechnology”, Springer, 2010.
2. Jennifer Kuzma and Peter VerHage, “Nanotechnology in agriculture and food production”, Woodrow Wilson International Center, 2006.
3. Brown P. J. and K. Stevens, “Nanofibers and Nanotechnology in Textile”s, Woodhead Publishing Limited, Cambridge, 2007.

REFERENCE BOOKS:

1. Neelina H. Malsch (Ed.), “Biomedical Nanotechnology”, CRC Press, 2005.
2. Maqhong fan, C.P. Huang, Alan E. Bland “Environanotechnology”,Elsevier,2010
3. Udo H. Brinker, Jean-Luc Mieusset (Eds.), “Molecular Encapsulation: Organic Reactions in Constrained Systems”,Wiley Publishers, 2010
4. Lynn J. Frewer, WillehmNorde, R. H. Fischer and W. H. Kampers “Nanotechnology in the

Agri-food sector",Wiley-VCH Verlag,2011.
5. Y-W. Mai, "Polymer Nano composites", Woodhead publishing, 2006.
6. Mark A. Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson ,2003
7. W.N. Chang, "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009

NANODEVICES AND APPLICATIONS

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: V

Subject Code	17NT563	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT - 03

Course Objective:
To understand the fundamental concepts of nanosensors and devises
To understand the working and circuitry of nanosensors and devices

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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, AMR, Giant and colossal magnetoresistors, magnetic tunnelling junctions.	08	L1, L2, L3

Module 3: NANOELECTROMECHANICAL SYSTEMS (NEMS) Introduction- Nano machining of NEMS based upon electron beam lithography, Nano electromechanical systems fabrication, nano imprint lithography, polymeric nano fiber templates, focused ion beam doping wet chemical etching, stencil lithography and sacrificial etching, large scale intergration, future challenges, applications.	08	L1, L2, L3
Module 4: NANOPARTICLES FOR SENSORS AND CIRCUITRY Photoinduced Electron Transport in DNA: Electronic Devices Based on DNA Architecture, DNA Nanowires, Charge Transport, DNA-Based Nanoelectronics, Electrical Manipulation of DNA on Metal Surfaces, Nanostructured Biocompartments, DNA-Gold nanoconjugates. Applications of alldevices.	08	L1, L2, L3, L4
Module 5: NANO-BIOLOGICAL SENSOR DEVICES 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.	08	L1, L2, L3, L4
Course Outcome: After completion of this course students can able To learn the fundamental concepts of nanosensors and devises To understand the working and circuitry of nanosensors and devices		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
TEXT BOOKS: 1. Kouroush Kalantar – Zaheb, Benjamin Fry, Nanotechnology enabled sensors, Springer Verlag, New York, 2007 2. Jerome Schults, Milar Mrksich, Sangeeta N. Bhatia, David J. Brady, Antionio J. Ricco, David R. Walt, Charles L. Wilkins,, Biosensing: International Research and Developments, Spinger, 2006 3. Ramon Pallas – Areny, John G. Webster John, Sensors and signal conditioning, 2nd edition, Wiley & Sons, 2001 4. Karl Glosekotter, Nanoelectronics and Nanosystems, Springer, 2004		

REFERENCE BOOKS:
1. Handbook of Biosensors and Electronic Noses: Medicine, Food and the Environment: CRC-Press, 1st Edition, 1996
2. D. L. Wise, Biosensors: theory and applications, CRC Press, 1993
3. Rao and Gupta, Principles of Medical Electronics and Biomedical Instrumentation, Orient Longman, 2001
4. H. Fujita, Micromachines as tool for Nanotechnology, Springer, 2003

NANOMATERIALS SYNTHESIS AND CHARACTERIZATION TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: V

Subject Code	17NT564	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT - 03

Course Objective:
To provide students with the knowledge of techniques used for synthesis and characterization of nanomaterials

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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 vapor Deposition (PVD) – Chemical vapour Deposition (CVD) - Atomic layer Deposition (ALD).	08	L1, L2
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,	08	L1, L2, L3

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.	08	L1, L2, L3
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3, L4
Course Outcome: On completion of this course, students should be able to: • Experiment Top-down approaches: physical techniques used for synthesis and processing of nanomaterials • Analyze Bottom-Up Approaches: chemical methods used for synthesis and processing of nanomaterials • Select biological methods used for synthesis and processing of nanomaterials; • Test Characterization of nanoparticels		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each		

module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. Microbiology by Michael J Pelczar Jr Chan ECS, Noel R Krieg, Tata McGraw Hill Publishing co Ltd 2. Microbiology by Prescott, Harley, Klein, McGraw Hill 3. Lehninger - Principles of Biochemistry by David L. Nelson and Michael M. Cox, 5th Edition, WH Freeman and Company 4. Principles of Biochemistry by Lubert Stryer, Freeman Int. Edition
REFERENCE BOOKS: 1. T. Pradeep, "NANO The Essential, understanding Nanoscience and Nanotechnology". Tata McGraw - Hill Publishing Company Limited, 2007 2. C. A. Mirkin and C. M. Niemeyer, Nanobiotechnology - II, More Concepts and Applications, WILEY-VCH, Verlag GmbH & Co, 2007

NANO MATERIALS SYNTHESIS LAB [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: V			
Laboratory Code	17NTL57	IA Marks	40
Number of Lecture Hours/Week	01Hr Instruction + 02 Hrs Laboratory	Exam Marks	60
		Exam Hours	03
CREDIT - 02			
Course Objective: • To understand the chemical approach to synthesize nano particles. • To synthesize nano materials by various chemical methods.			
List of Experiments			Revised Bloom's Taxonomy (RBT) Level
1. Synthesis of Ferro fluids by chemical method			L2,L4,L5
2. Synthesis of Ag metal nano particles by Chemical reduction method			L2,L3,L4
3. Synthesis of TiO_2 nano particles by Solvothermal method.			L2,L3,L4
4. Synthesis of Fe_2O_3 nano particles by Co-precipitation method			L5,L6
5. Synthesis of Mn_3O_4 nano particles by Co-precipitation method			L5,L6
6. Synthesis of Au metal nano particles by Chemical reduction method			L2,L3,L4
7. Synthesis of ZnS/MoS nano particles by microwave Solvothermal method			L5,L6
8. Synthesis of Fe_3O_4 nano particles by chemical reduction method			L2,L3,L4

9. Synthesis of CuO nano particles by reverse microemulsion method	L2,L3,L4
10. Synthesis of MoS_2 nano particles by ultra-sonication method.	L5,L6
11. Synthesis of monodisperse copper nano particles by chemical reduction method.	L5,L6
12. Synthesis of CdS by chemical method	L2,L3,L4
13. Synthesis of nano crystalline AgS	L2,L3,L4
14. Synthesis of ZnO by chemical method	L2,L3,L4
15. Green synthesis of Ag nano particles	L2,L3,L4
Course Outcome: Students can able to learn the different techniques to synthesis nano materials.	
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.	
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.	
REFERENCE BOOKS: 1. Lab manual	

CHARACTERIZATION AND MEASUREMENT LAB [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: V			
Laboratory Code	17NTL58	IA Marks	40
Number of Lecture Hours/Week	01Hr Tutorial + 02 Hrs Laboratory	Exam Marks	60
		Exam Hours	03
CREDIT - 02			
Course Objective: • 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 also to identify the unknown materials.			

List of Experiments	Revised Bloom's Taxonomy (RBT) Level
1. Determination of electromagnetic properties of N-type and P-type semiconductors.	L2,L4,L5
2. Determination of ionic conductivity of a given sample.	L2,L3,L4
3. Determination of thermal conductivity of thin films.	L2,L3,L4
4. Determination of optical properties of a given sample.	L5,L6
5. Measurement of mechanical properties of a given sample.	L5,L6
6. Determination of magnetic properties of a given liquid sample.	L2,L3,L4
7. Determination of efficiency of a given solar cell.	L5,L6
8. Determination of ultrasonic sound velocity of given liquid samples.	L2,L3,L4
9. Identification of unknown sample by arc spectrum method.	L2,L3,L4
10. Resistivity determination for a semiconductor wafer using Four probe method.	L5,L6
11. To trace the hysteresis loop for a magnetic material.	L5,L6
12. Determination of wavelength of the given LED.	L2,L3,L4
13. Measurement of thickness of a given thin film by air wedge method.	L2,L3,L4

Course Outcome:

- 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.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS:

1. Lab manual

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B.E. Nano Technology

Semester: VI

Core Subjects

QUANTUM MECHANICS AND SIMULATION TECHNIQUES [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VI			
Subject Code	17NT61	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT – 04			
Course Objective: • To understand the basic principles of quantum mechanics and simulation methods. • To learn the application of the simulation techniques in biology and biomedical fields.			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.		10	L1, L2
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.		10	L1, L2, L3
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.		10	L1, L2, L3, L4

(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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3

Course Outcome:
Students can able to learn

- Physical basics of quantum mechanics
- Basic principles of quantum mechanics
- Basics of Quantum computational simulation
- Basic principles of surgical simulation and virtual environment for biomedical applications
- Concepts of simulation methods and biological systems

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Basic Quantum Mechanics by -A. Ghatak (2009) ISBN 0-230-63916-X
2. Introductory Quantum Chemistry; A.K. Chandra; Tata McGraw Hill Publishing Company Limited. New Delhi, 1998
3. Quantum Mechanics: B. K. Agarwal and Hariprakash (Prentice-Hall, 1997).
4. Medical Informatics: Computer applications in health care and biomedicine by E. H. Shortliffe, G. Wiederhold, L. E. Perreault and L. M. Fagan, Springer Verlag.
Handbook of Medical Informatics by J. H. Van Bemmel, Stanford University Press
5. "Handbook of theoretical and computational Nanotechnology" eds. Michael Rieth and wolfram schommers, 2006.
6. Computational physics, R. C. Verma, K. C. Sharma & P. K. Ahluwalia.

REFERENCE BOOKS:

1. Text book of Quantum Mechanics: P. M. Mathews and K. Venkateshan (TMH, 1994).

2. Quantum Mechanics: F. Schwabl (Narosa, 1995).
3. Quantum Mechanics: V. K. Thankappan (Wiley Eastern, 1980).
4. Quantum Physics of Atoms, molecules, solids Nuclei and particles 2nd Ed by Eisberg, Robert, Resnick Robert
5. Jerrod H.Zar (1999) Biostatistical analysis by Prentice hall international Inc Press, London

PYTHON PROGRAMMING LANGUAGE FOR AUTOMATION

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Subject Code	17NT62	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDIT – 04

Course Objective:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
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.	10	L1, L2, L3
Module 3: **PYTHON – DECISION MAKING** If Statement, If else Statement, The elif Statement, Single	10	L1, L2, L3, L4

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** 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.	10	L1, L2, L3, L4
Module 5: **PYTHON – LISTS** 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. **PYTHON – TUPLES** 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.	10	L1, L2, L3
Course Outcome: After completion of this course students will be able to: • Understand the basic syntax of python programming language • Understand and apply the basic operation of python programming language • Understand and apply the python decision making and python loops • Understand and apply the python numbers and strings • Understand and apply the python lists and tuples		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
TEXT BOOKS:		

1. Mark Lutz, Learning Python, 5th Edition, ISBN: 978-1-449-35573-9
2. Allen Downey, Think Python: An Introduction to Software Design, ISBN: 1466367296, 9781466367296

REFERENCE BOOKS:
1. Python Programming Language, tutorialspoint, www.tutorialspoint.com

MOLECULAR BIOLOGY AND GENETIC ENGINEERING
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Subject Code	17NT63	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDIT – 04

Course Objective:
- 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.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: MOLECULAR GENETICS DNA as genetic material, classical experiments – Hershey and chase; AveryMcLeod & McCarty. Bacterial conjugation, transduction and transformation, prokaryotic andeukaryotic genome organization.	10	L1, L2
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.	10	L1, L2, L3
Module 3: TRANSLATION Elucidation of genetic code, Process of translation in prokaryotes and eukaryotes, posttranslational modifications, Suppressor	10	L1, L2, L3, L4

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	10	L1, L2, L3, L4
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.	10	L1, L2, L3

Course Outcome:
After completion of this course students will be able to:

- Understand molecular genetics
- Understand replication and transcription
- Understand translation
- Understand recombinant DNA technology
- Apply the knowledge of rDNA technology

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1.Primrose SB & Twyman, "Principles Of Gene Manipulation, An Introduction To Genetic Engineering ", Blackwell Science Publications, 2006.
2. Molecular Biology and Genetic Engineering, Dr. Prasad Puthiyillam, LAP-Lambert Academic Publishing, Mauritius, 2018. ISBN: 978-613-9-82325-3
3. David Friefelder, Molecular Biology, Narosa Publ. House, 1999

REFERENCE BOOKS:

1. Sandhya Mitra, “Genetic Engineering Principles and Practice”, Rajiv Beri for Macmillan IndiaLtd publications, 2008.
2. P. K. Gupta, “Elements of biotechnology”, Rastogi publications, 2004.
3. Gardner / Simmons / Snustad, Principles of Genetics, Eighth Edition, John Wiley, 2000.

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MICRO FLUIDICS AND NANO FLUIDS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT64	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT – 04			
Course Objective: • To study basic principles of micro and nano fluids • To understand the synthesis advantages and importance of micro and nanofluids			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.		10	L1, L2
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.		10	L1, L2, L3
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		10	L1, L2, L3, L4

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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3
Course Outcome: Students can learn • To study basic principles of micro and nano fluids • To understand the synthesis advantages and importance of micro and Nano fluids		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly).		

• Interpretation of data.
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1.Nanofluids:Science and Technology, Sarit K. Das, Stephen U. S. Choi, Wenhua Yu, T. Pradeep, 2008 John Wiley & Sons, Inc. 2. PatricTabeling, "Introduction to Microfluids", Oxford U. Press, New York , 2005
REFERENCE BOOKS: 1.Eric K. Sackmann, Anna L. Fulton, David J. Beebe, The present and future role of microfluidics in biomedical research, doi:10.1038/nature13118 2. Ankur Gupta, H. BurakEral, T. Alan Hatton, Patrick S. Doyle, Nanoemulsions: formation, propertiesand applications, Soft Matter, Royal Society of Chemistry, DOI: 10.1039/c5sm02958a 3. R.Saidura, K.Y.Leongb, H.A. Mohammad, A review on applications and challenges of nanofluids, Elsevier, doi.org/10.1016/j.rser.2010.11.035

Professional Elective Subjects

HYBRID CIRCUITS AND PACKAGING [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VI			
Subject Code	17NT651	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: • To understand the basics of hybrid microcircuits, mathematical foundations and CAD design for hybrid microcircuits • To learn packaging of electronic devices, techniques for nano and bio packaging, nanomaterials for packaging • To design and develop 3D models for packaging			
Modules		Teaching Hours	Revised Bloom's Taxonomy

		(RBT) Level
Module 1: HYBRID MICROCIRCUIT INTRODUCTION Microcircuit family, need for hybrid microcircuits, applications of microcircuits, typical microelectronic products	08	L1, L2
Module 2: MATHEMATICAL FOUNDATIONS OF HYBRID CIRCUITS Mathematical foundations, circuit design and layout rules, Computer aided design and pattern generation	08	L1, L2, L3
Module 3: FUTURE OF PACKAGING Packaging for Electronic systems, system integration by advanced electronics packaging, nano and bio techniques for electronic device packaging	08	L1, L2, L3, L4
Module 4: 3D MODELLING AND DESIGN FOR NEMS 3D design, 3D data structures for nanoscale design	08	L1, L2, L3, L4
Module 5: NANOMATERIALS FOR MICROELECTRONIC AND BIO PACKAGING packaging of bio-micro-electro-mechanical systems (BIOMEMS) and microfluidic chips, packaging of miomolecular and chemical microsensors	08	L1, L2, L3

Course Outcome:
After successfully completing this course, students will be able to:

- Understand the fundamentals of hybrid micro circuits and importance of hybrid circuits in various industries
- Evaluate and determine the standards, technological challenges and future trends of nano and bio techniques for electronic device packaging
- Initiate, innovate and develop nanotechnology based solutions in the field of electronics packaging

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Tapan K. Gupta, Handbook of Thick and Thin Film Hybrid Microelectronics, Wiley Interscience, John Wiley & Sons, 2003.

2. http://onlinelibrary.wiley.com/doi/10.1002/0471723673.fmatter/pdf
3. Gerald Gerlach, Klaus-Jürgen Wolter, Bio and Nano Packaging Techniques for Electron Devices: Advances in Electronic Packaging, Springer, 2012.
4. C.P. Wong, Kyoung-Sik Moon, Yi (Grace) Li, Nano-Bio- Electronic, Photonic and MEMS Packaging, Springer Science & Business Media, 2014.

REFERENCE BOOKS:

1. Gerald Gerlach, K.-F. Arndt, Hydrogel Sensors and Actuators: Engineering and Technology, Springer, 2009
2. Daniel Lu, C.P. Wong, Materials for Advanced Packaging, Springer, 2016
3. Yan Li, Deepak Goyal, 3D Microelectronic Packaging: From Fundamentals to Applications, Springer, 2017

NANOTECHNOLOGY IN AGRICULTURE AND FOOD PROCESSING

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Subject Code	17NT652	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:

- 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.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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	08	L1, L2

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.	08	L1, L2, L3
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.	08	L1, L2, L3
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3, L4
Course Outcome: Students can • Study the basic interaction of different molecules which are helpful in both food and agricultural activities • Understand the importance of nanomaterials and devices in precision farming, advanced materials used in agriculture and food industries.		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis.		

• Design / development of solutions (partly). • Interpretation of data.
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. Nicholas A. Kotov, "Nanoparticle Assemblies and Superstructures", CRC, 2006. 2. Jennifer Kuzma and Peter VerHage, "Nanotechnology in agriculture and food production", Woodrow Wilson International, 2006.
REFERENCE BOOKS: 1. David S. Goodsell, "Bionanotechnology", John Wiley & Sons, 2004. 2. Balaji Sitharaman "Nanobiomaterials Handbook", Taylor & Francis Group, 2011. 3 Food Processing, Management And Nanotechnology Author: Annish Chauhan, *et.al*.,; ISBN: 978 93 5056 796 8; Year: 2016; Pages: 198

CERAMIC MATERIALS AND THEIR APPLICATIONS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VI			
Subject Code	17NT653	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: • A course designed to expose students to the fundamental knowledge and concept of different areas of ceramics and applications. • It is designed to introduce the special characteristics and fabrication methods of different classes of ceramics.			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: FUNDAMENTALS OF CERAMICS		08	L1, L2

Definition & scope of ceramics and ceramic materials. Examples of ceramic crystals, short-range and long-range order, imperfections, polymorphism. Ceramic Binary and ternary systems, ceramic microstructures. Crystallization of glass and glass-ceramics.		
Module 2: PROPERTIES, CLASSIFICATION AND APPLICATIONS OF CERAMICS Thermal, electrical, magnetic and optical properties of ceramics and application. Classification of ceramic materials conventional and advanced, Areas of applications.	08	L1, L2, L3
Module 3: CONVENTIONAL CERAMICS Refractories: Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application. Whitewares: Classification and type of Whitewares, Elementary idea of manufacturing process technology including body preparation, basic properties and application areas. Ceramic Coatings: Types of glazes and enamels, Elementary ideas on compositions, Process of enameling& glazing and their properties. Glass: Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses. Application of glasses. Cement & Concrete: Concept of hydraulic materials, Basic raw materials, Manufacturing process, Basic compositions of OPC. Compound formation, setting and hardening. Tests of cement and concrete.	08	L1, L2, L3, L4
Module 4: RAW MATERIALS AND FABRICATION METHODS Elementary ideas about the raw materials used in pottery, Heavy clayweres, Refractories, Glass, Cement, Industries. Raw materials clays and their classification, Quartz, Polymorphism of quartz, Feldspar and its classification, Talc, Steatite and Mica. Fabrication methods, Packing of Powders, Classification and scope of various fabrication methods. Dry and semi dry pressing, extrusion, Jiggering & jollying, Slip casting HP & HIP. Drying & Firing of ceramics: Biscuit firing and glost firing, fast firing technology, action of heat on triaxial body, Elementary ideas of various furnaces used is ceramic industries.	08	L1, L2, L3, L4
Module 5: ADVANCED CERAMICS Engineering ceramics, ceramics used in advanced applications, ceramics for medical and scientific products, ceramics for electrical and electronic, aerospace.	08	L1, L2, L3
Course Outcome: After completion of the course students will be exposed to: • The fundamental knowledge and concept of different areas of ceramics and		

applications.
- The special characteristics and fabrication methods of different classes of ceramics.

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:
- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:
1) Elements of Ceramics - F.H Norton
2) Fundamentals of Ceramics - Barsoum
3) Introduction to Ceramics - W.D Kingery
4) Smith - Materials Science
5) Industrial Ceramics - Singer & Singer. 4.2

REFERENCE BOOKS:
1) Refractories - J. H. Chester
2) Chemistry of Glasses - A. Paul
3) Ceramic Whitewares - SudhirSen
4) Chemistry of cement - F.M. Lea
5) Cera. Mat. for Electronics - R.C Buchanon

SURFACE SCIENCE AND THIN FILM TECHNOLOGY
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Subject Code	17NT654	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

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

Modules	Teaching Hours	Revised Bloom's

		Taxonomy (RBT) Level
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.	08	L1, L2
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.	08	L1, L2, L3
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.	08	L1, L2, L3
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-	08	L1, L2, L3, L4

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.	08	L1, L2, L3
Course Outcome: Students can understand • surface science and interfaces, • thin films and coating, • thin film deposition, • atomic layer deposition, • mechanism of anti-reflective coating and self-cleaning glass, and • nano indentation.		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
TEXT BOOKS: 1. S. Grainger and J. Blunt, Engineering Coatings: Design and Application, Woodhead Publishing Ltd, UK, 2nd ed., 1998, ISBN 978-1-85573-369-5 2. Functional Polymer Films Eds. R. Advincula and W. Knoll – Wiley, 2011, ISBN 978-3527321902.		
REFERENCE BOOKS: 1. George, S.M. (2010). "Atomic Layer Deposition: An Overview". Chem. Rev. 110: 111–131. doi:10.1021/cr900056b		

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Open Elective Subjects

NANOTECHNOLOGY IN ELECTRICAL AND ELECTRONICS ENGINEERING [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VI			
Subject Code	17NT661	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: • 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			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: **ENERGY PRODUCTION** Nanotechnology and Applications for Electric Power: The Perspective of a Major Player in Electricity, Lightweight Nanostructured Materials and Their Certification for Wind Energy Applications		08	L1, L2
Module 2: **ENERGY STORAGE AND DISTRIBUTION** Carbon Nanotube Wires and Cables: Near-Term Applications and Future Perspectives, Carbon Nanotube Materials to Realize High-Performance Supercapacitors		08	L1, L2, L3
Module 3: **ENERGY CONVERSION AND HARVESTING** Nanostructured Thermoelectric Materials: Current Research and Future Challenges. Energy Consumption in Information and Communication Technology: Role of Semiconductor Nanotechnology		08	L1, L2, L3, L4
Module 4: **NANOENABLED MATERIALS AND COATINGS FOR ENERGY APPLICATIONS** Nanocrystalline Bainitic Steels for Industrial Applications, Graphene and Graphene Oxide for Energy Storage		08	L1, L2, L3, L4

Module 5: NANOTECHNOLOGY IN TELECOMMUNICATIONS Impact of Nanotechnology on Telecommunications, Nanotubes and Their Applications in Telecommunications, Quantum Dot Cellular Automata: The Prospective Technology for Digital Telecommunication Systems	08	L1, L2, L3

Course Outcome:
After successfully completing this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Baldev Raj, Marcel Van de Voorde, YashwantMahajan, Nanotechnology for Energy Sustainability, Wiley-VCH Verlag GmbH & Co. KGaA, 2017
http://onlinelibrary.wiley.com/book/10.1002/9783527696109
2. Sohail Anwar, M. Yasin Akhtar Raja, Salahuddin Qazi, Mohammad Ilyas, Nanotechnology for Telecommunications, CRC Press, 2017
https://www.crcpress.com/Nanotechnology-for-Telecommunications/Anwar-Raja-Qazi-Ilyas/p/book/9781138113817

REFERENCE BOOKS:

1. Manijeh Razeghi; Leo Esaki; Klaus von Klitzing, The Wonder of Nanotechnology: Quantum Optoelectronic Devices and Applications, SPIE PRESS BOOK, 2013
2. Puers Robert, Baldi Livio, Van de Voorde Marcel, van Nooten, Sebastiaan E., Nanoelectronics: Materials, Devices, Applications, Wiley-VCH, Weinheim, 2017

NANOTECHNOLOGY IN CIVIL AND ENVIRONMENTAL ENGINEERING
[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Course: B.E. / Nano Technology Semester: VI			
Subject Code	17NT662	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			

Course Objective:

- 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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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	08	L1, L2, L3
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.	08	L1, L2, L3, L4

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, Nanoindentation techniques, Neutron and X-ray scattering techniques for construction materials	08	L1, L2, L3
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.	08	L1, L2, L3, L4

Course Outcome:

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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Khitab Anwar, Advanced Research on Nanotechnology for Civil Engineering Applications, IGI Global, May 16, 2016 - Technology & Engineering - 339 pages
2. ZdenekBittnar, Peter J. M. Bartos, Jiri Nemecek, V. Smilauer, J. Zeman, Nanotechnology in

Construction: Proceedings of the NICOM3, Springer Science & Business Media, Apr 21, 2009 - Technology & Engineering - 437 pages
3. M.S. Ramachandra Rao, Shubra Singh, Nanoscience and Nanotechnology: fundamentals to Frontiers, Wiley 2013
4. G Cao, Nanostructures and Nanomaterials synthesis, properties and applications, Imperial College press 2004.

REFERENCE BOOKS:

1. W. Zhu 1, P.J.M. Bartos 1 and A. Porro, Materials and Structures / Mat6riaux et Constructions, RILEM TC 197-NCM: 'Nanotechnology in construction materials' Application of nanotechnology in construction Summary of a state-of-the-art report Prepared 2 Vol. 37, November 2004, pp 649-658
2. Florence Sanchez, Konstantin Sobolev, Nanotechnology in concrete – A review, Construction and Building Materials 24 (2010) 2060–2071
3. G.A. Mansoori, T. Rohani. Bastami, A. Ahmadpour, Z. and Eshaghi, Chapter 2 Environmental Application Of Nanotechnology, Annual Review of Nano Research, Vol.2, Chap.2, 2008
4. Ian SofianYunus, Harwin, AdiKurniawan, DendyAdityawarman and Antonius Indarto, Nanotechnologies in water and air pollution treatment, Environmental Technology Reviews Vol. 1, No. 1, November 2012, 136–148
5. JieZhuang and Randall W. Gentry, Environmental Application and Risks of Nanotechnology: A Balanced View, In Biotechnology and Nanotechnology Risk Assessment: Minding and Managing the Potential Threats around Us; Ripp, S., et al.; ACS Symposium Series; American Chemical Society: Washington, DC, 2011.

NANOTECHNOLOGY IN MECHANICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Subject Code	17NT663	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:

- To learn the different aspects of nanotechnology which can improve the field of Mechanical Engineering
- To understand the designing, fabricating, developing and analysing the materials by nanotechnology

Modules	Teaching Hours	Revised Bloom's

		Taxonomy (RBT) Level
Module 1 NANOSTRUCTURES IN MECHANICAL ENGINEERING Introduction to Nanomaterials- Quantum dot, CNT, fullerenes, buckyball, nanocomposites and nanoceramics, mechanical properties of nanomaterials, applications of nanomaterials in Mechanical engineering, Assembly of nanoparticles and functionalization - Nanoparticles arranged structures as Nanopores and Nanocomposites - Structure control of nanoparticle collectives by sintering and bonding - Self-assembly. Nanoparticle dispersion and aggregation behavior - Single nanoparticle motion in fluid – Brownian diffusion - Adsorption properties - Interactions between particles	08	L1, L2
Module 2 MACHINING BRITTLE MATERIALS USING NANOSTRUCTURED DIAMOND TOOLS Introduction, Mechanisms of Tool Wear- classification of tool types, Machining Simulations, Experimental Method- Deposition cycles for TMCVD panel and TMCVD panel, characterization- Film characterization, Wear mechanisms- Crater wear and notching wear, Flank wear, Cutting forces and friction coefficient.	08	L1, L2, L3, L4
Module 3 ANALYSIS OF CONTACT BETWEEN CHIP AND TOOL USING NANOSTRUCTURED COATED CUTTING TOOLS Introduction, Computational Analysis of Machining Conditions- Loewen and Shaw's Method to Calculating Cutting Temperatures, Finite Element Studies of Machining Conditions- Coefficient of Friction, Shear Plane Temperature vs Coefficient of friction and Tool Face Temperature vs Coefficient of Friction.	08	L1, L2, L3
Module 4 FORMATION OF NANOSTRUCTURED METALS BY MACHINING Introduction, Chip Formation- Chip Curl Modelling and Shear Strains, Chip Formation with Modulation, Computational Analysis, Experimental Procedure- Finite Element Analysis, Micro-grinding Experiments, Chip Curl Modelling, Finite Element Modelling and Micro-grinding Observations.	08	L1, L2, L3, L4
Module 5 MANUFACTURE AND DEVELOPMENT OF NANOSTRUCTURED DIAMOND TOOLS Introduction, Analysis of Stress in a Loaded Wedge- Stress analysis of a single-point loaded wedge, Stress Analysis in a Wedge with a Distributed Load, Development of Wear Model, Computational Stress Analysis of Single Diamond Grains, Experimental Methods- Hot filament chemical vapor deposition, Measurement of wear of diamond tools.	08	L1, L2, L3
Course Outcome: • Students will learn the different aspects of nanotechnology which can improve the		

field of Mechanical Engineering • Students are able to understand the designing, fabricating, developing and analysing the materials by nanotechnology
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. Mark J. Jackson Jonathan S. Morrell "Machining with Nanomaterials" 2009 Springer ISBN 978-0-387-87659-7 2. Edward L. Wolf, "Nanophysics and Nanotechnology - An Introduction to Modern Concepts in Nanoscience" Second Edition, John Wiley & Sons, 2006.
REFERENCE BOOKS: 1. K.W. Kolasinski, "Surface Science: Foundations of Catalysis and Nanoscience", Wiley, 2002

NANOTECHNOLOGY IN BIOMEDICAL ENGINEERING [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VI			
Subject Code	17NT664	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: • 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 etc.			
Modules		Teaching	Revised

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

	Hours	Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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	08	L1, L2, L3
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3
Course Outcome: Students can • Learn the basic importance and applications of Nanotechnology medical and biological fields.		

- Understand techniques and design the nanostructures, nanodevices, nano based diagnostics techniques, therapeutics and devices as implants, drug delivery devices, etc.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Malsch, N.H., "Biomedical Nanotechnology", CRC Press. (2005)
2. Nanotechnology in Biomedical Engineering, Abhinaya Nellerichale, LAP-Lambert Academic Publishing,Mauritius, 2018, ISBN: 978-613-9-83115-9
3. Mirkin, C.A. and Niemeyer, C.M., "Nanobiotechnology II: More Concepts and Applications", Wiley-VCH. (2007)
4. Kumar, C. S. S. R., Hormes, J. and Leuschner C., "Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact", WILEY -VCH Verlag GmbH & Co. (2005)

REFERENCE BOOKS:

1. K. K. Jain, "The Handbook of Nanomedicine", Humana press. (2008)
2. M. Reza Mozafari, Nanomaterials and Nanosystems for Biomedical Applications, Springer. (2007)
3. P. P. Simeonova, N. Opopol and M.I. Luster, "Nanotechnology - Toxicological Issues and Environmental Safety", Springer 2006.
4. Vinod Labhasetwar and Diandra L. Leslie, "Biomedical Applications of nanotechnology", A John Willy& son Inc,NJ, USA, 2007.
5. Challa, S.S.R. Kumar, Josef Hormes, & Carola Leuschaer, Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact, Wile- VCH, (2005)

MOLECULAR BIOLOGY AND GENETIC ENGINEERING LAB

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Laboratory Code	17NTL67	IA Marks	40
Number of Lecture	01Hr Instruction + 02 Hrs	Exam	60

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Hours/Week	Laboratory	Marks	
		Exam Hours	03
CREDIT – 02			
Course Objective: • 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.			
List of Experiments			Revised Bloom's Taxonomy (RBT) Level
1. Study of divisional stages in Mitosis.			L2,L4,L5
2. Study of divisional stages in Meiosis.			L2,L3,L4
3.Study of slides of human cells			L2,L3,L4
4. Study of Polytene and Lampbrush chromosomes using permanent slides			L2,L3,L4
5. Isolation of genomic DNA from onion			L5,L6
6. Isolation of plasmid DNA from *bacteria*			L5,L6
7. Isolation of genomic DNA from banana			L2,L3,L4
8. Agarose gel electrophoresis and quantification of nucleic acids (colorimetric, ethidium bromide dot blot and standard DNA marker)			L5,L6
9. Isolation of RNA from yeast			L2,L3,L4
10. Study of conjugation in *E.coli*			L5,L6
11. Amplification of DNA by PCR			L5,L6
12. Preparation of DNA for PCR applications- Isolation, purity & quantification			L2,L3,L4
Course Outcome: • 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.			
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.			
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.			
TEXT BOOKS:			

1. Looking at Chromosomes by Darlington, Wiley.
2. Essentials of Molecular Biology by David Freifelder, Narosa Pub. House.
3. Molecular Biology of the Cell by Alberts et al., Garland Publishing.
4. Principles of Gene manipulation and Genomics by Primrose, Oxford University Press.
5. Molecular Biology of the Gene by James D Watson et al., Pearson Education.

REFERENCE BOOKS:
1. Molecular Cell Biology by Darnell J Lodish & H Baltimore, Freeman Pub.
2. Biochemistry & Molecular Biology by William H Elliot and Daphane C Elliot, Oxford University Press.
3. Current protocols in molecular biology, edited by Frederick M. Ausubel et al., John Wiley & Sons.
4. Methods in enzymology by Berger S.L. & Kimmel A.R., Vol.152, Academic Press.
5. Cellular & Biochemical Science by G. Tripathi, IK Intl.

QUANTUM MECHANICS AND SIMULATION LAB

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Laboratory Code	17NTL68	IA Marks	40
Number of Lecture Hours/Week	01Hr Instruction + 02 Hrs Laboratory	Exam Marks	60
		Exam Hours	03

CREDIT – 02

Course Objective:
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, etc.

List of Experiments	Revised Bloom's Taxonomy (RBT) Level
1. Modelling metal–semiconductor contacts: The Ag–Si interface using QuantumWise - Virtual NanoLab Software	L5,L6
2. Resistivity calculations using the MD-Landauer method using QuantumWise - Virtual NanoLab Software	L5,L6
3. Spin-orbit transport calculations: Bi2Se3 topological insulator thin-film device using QuantumWise - Virtual NanoLab Software	L5,L6
4. Opening a band gap in silicene and bilayer graphene with an electric field using QuantumWise - Virtual NanoLab Software	L5,L6
5. Building molecule–surface systems: Benzene on Au (111) using QuantumWise - Virtual NanoLab Software	L5,L6
6. Spin-dependent Bloch states in graphene nanoribbons using	L5,L6

QuantumWise - Virtual NanoLab Software	
7. Exploring graphene - Build a graphene sheet - Build a CNT - Transmission spectrum of a GNR using QuantumWise - Virtual NanoLab Software	L5,L6
8. Twisted nanoribbon - Transmission spectrum - Buckling a graphene sheet.	L5,L6
9. Sequence retrieval from nucleic acid and protein data base using NCBI	L2,L3,L4
10. Multiple alignment of sequence and pattern determination by NCBI and Clustal Omega Prosite software	L2,L3,L4
11. Evolutionary studies / phylogenetic analysis by phylowin software and Visualization by TreeView software	L2,L3,L4
12. Secondary structure prediction of proteins by Sopma software	L2,L3,L4
13. Identification of functional sites in gene / genome by Gen Sean and ORF finder software	L2,L3,L4
14. Super imposition of molecular structures and calculation of RMSD by SPDBV software	L2,L3,L4
15. PDB structure retrieval and visualization; analysis of homologous structure by RASMOL software	L2,L3,L4
Course Outcome: Students can understand • The simulation at atomic and molecular level by using softwares • About the nucleic acids, proteins, superimposition of molecules and building the phylogenetic tree.	
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.	
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.	
REFERENCE BOOKS: 1. Lab manual	

Semester: VII

Core Subjects

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

NANOCOMPOSITES AND THEIR APPLICATIONS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT71	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT – 04			

Course Objective:

- 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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
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). Laminates: Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates; applications of PMC in aerospace, automotive industries. Applications of polymer nanocomposites	10	L1, L2, L3
Module 3: **METAL MATRIX COMPOSITES** Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC,	10	L1, L2, L3, L4

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, applications of MMC in aerospace, automotive industries. Applications of Metal matrix nanocomposites.		
Module 4: CERAMIC MATRIX 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, aluminium oxide, silicon nitride; Reinforcements: particles, fibres, whiskers. Sintering, Hot pressing, Cold isostatic pressing (CIPing), Hot isostatic pressing (HIPing). Processing of Ceramic Matrix composites. Applications of ceramic matrix nanocomposites Applications of CMC in aerospace, automotive industries. Carbon/carbon composites, advantages of carbon matrix, limitations of carbon matrix. Carbon fibre – chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique	10	L1, L2, L3, L4
Module 5: MECHANICS OF COMPOSITES Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. QuasiIsotropic Laminates. Determination of Lamina stresses within Laminates.	10	L1, L2, L3
Course Outcome: After completion of course, student can be able to • Design composites using of different material • Use different techniques to process different types of composites and know the limitations of each process • Use Mathematical techniques to predict the macroscopic properties of different Laminates		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions.		

- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Mathews F. L. and Rawlings R. D., "Composite Materials: Engineering and Science", 1 st Edition, Chapman and Hall, London, England, 1994.
2. Chawla K. K., "Composite materials", Second Edition, Springer – Verlag, 1998.

REFERENCE BOOKS:

1. Clyne, T. W. and Withers, P. J., "Introduction to Metal Matrix Composites", Cambridge University Press, 1993.
2. Strong, A.B., "Fundamentals of Composite Manufacturing", SME, 1989.
3. Sharma, S.C., "Composite materials", Narosa Publications, 2000.
4. Broutman, L.J. and Krock,R. M., "Modern Composite Materials", Addison-Wesley, 1967. 5. ASM Hand Book, "Composites", Vol.21, ASM International, 2001.

MICROCONTROLLERS AND INTERFACE

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VI

Subject Code	17NT72	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03

CREDIT – 04

Course Objective:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2, L3

Module 2: ADDRESSING MODES 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.	10	L1, L2, L3
Module 3: 8051 INSTRUCTION SET Instruction timings, 8051 instructions: Data transfer instructions, Arithmetic instructions, 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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3
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.	10	L1, L2, L3
Course Outcome: Students can • Study basic principles of micro-controllers family • Understand designing and interfacing the devices with micro controllers		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions.		

• Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. 8051 microcontroller : Hardware, software and applications by M S Mallikarjunaswamy and V Udayashankara 2. PIC microcontrollers for beginners, by NebojsaMatic. 3.The AVR microcontroller and embedded system by Muhammad alimazidi.
REFERENCE BOOKS: 1. The 8051 microcontroller and embedded systems Using assembly and C, 2nd ed., by Muhammad Ali Mazidi. ISBN: 9780131194021 2. The 8051 microcontroller, 3rd ed. By Kenneth Ayala, ISBN: 108131502007

MEMS AND NEMS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT73	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT – 04			
Course Objective: • To understand the basic components of MEMS and NEMS • To study, design the MEMS and NEMS based devices			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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,		10	L1, L2

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.	10	L1, L2, L3
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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3, L4
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.	10	L1, L2, L3
Course Outcome: Students can • understand the basic components of MEMS and NEMS • study, design the MEMS and NEMS based devices		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions.		

• Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. N. P. Mahalik, MEMS, Tata-McGraw Hill publication, 2009 2. V. K. Aatre, G. K. Ananthasuresh, K. J. Vinoy, Micro & Smart System, Wiley India, 2010. 3. Karlglosekotter, "Nanoelectronics and Nanosystems", Springer, 2004 KouroshKalantar-zadeh, Benjamin Fry, "Nanotechnology-Enabled Sensors", springer.
REFERENCE BOOKS: 1. Michael Stroscio, MitraDutta, Biological nanostructures and applications of nanostructures in biology, Kluwer academic publishers, 2004. 2. H. Fujita, Micromachines as Tools for Nanotechnology, Springer, 2003. 3. J.B. Park, Biomaterials Science and Engineering, Ed. 2, Narosa Publishers, New Delhi, 2005

Professional Elective Subjects

DATA ANALYTICS IN NANOSCIENCE [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT741	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: • To understand the basics of big data analytics, methods and tools that data scientists use • To learn the concepts, principles and practical applications of data analytics in nanotechnology • To learn the method and procedures of using open source software for big data analytics			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: INTRODUCTION TO BIG DATA ANALYTICS Big data overview, data structures, analyst prespective on data		08	L1, L2

repositories, state of the practice in analytics, current analytical architecture, drivers of big data, emerging big data ecosystem, new big data ecosystem, examples of big data analytics		
Module 2: DATA ANALYTICS LIFECYCLE Life cycle, discovery, data preparation, model planning, model building, communicate results, operationalize, global innovation networks and analysis, discovery	08	L1, L2, L3
Module 3: DATA ANALYTIC METHOD USING R Introduction to R, exploratory data analysis, statistical methods for evaluation.	08	L1, L2, L3, L4
Module 4: ANALYTICAL THEORY AND METHODS Introduction to clustering, association rules, regression, classification, time series analysis, text analysis, mapreduce and hadoop, in database analytics	08	L1, L2, L3, L4
Module 5: CONVERGENCE OF NANOTECHNOLOGY AND BIG DATA ANALYSIS Big Data; biosensors; computer-aided diagnosis; data analysis; data visualization; healthcare; nanotechnology	08	L1, L2, L3

Course Outcome:
After successfully completing this course, students will be able to:

- Understand the fundamentals of data analytics and big data
- Develop structured lifecycle approach to data analytics problems
- Apply appropriate analytic technique and tools to analyse big data in nanotechnology

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, 2015. (http://as.wiley.com/WileyCDA/WileyTitle/productCd-111887613X.html)
2. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, 2015. (http://as.wiley.com/WileyCDA/WileyTitle/productCd-111887613X.html)

3. Rodrigues JF, Paulovich FV, de Oliveira MC, de Oliveira ON, On the convergence of nanotechnology and Big Data analysis for computer-aided diagnosis, Nanomedicine (Lond). 2016 Apr;11(8):959-82. doi: 10.2217/nnm.16.35. Epub 2016 Mar 16 (https://www.ncbi.nlm.nih.gov/pubmed/2697966)

REFERENCE BOOKS:

1. Ramona Nelson, Nancy Staggers, Health Informatics - E-Book: An Interprofessional Approach, Elsevier, 2014

NANOTECHNOLOGY FOR HEALTHCARE

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VII

Subject Code	17NT742	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:

- To learn the basic principles and importance of Nanobiotechnology health care.
- To understand and design the nanostructures, nanodevices, nano based diagnostics techniques and devices as implants, drug delivery devices etc.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: NANOTECHNOLOGY IN PHARMACEUTICAL APPLICATIONS Human anatomy – Form function and physiology – Developmental prolog - principle of development – Neurophysiology – sensory physiology and muscle physiology – Trends in nanobiotechnology - Protein- and peptide-based compounds for cancer, diabetes, infectious diseases and organ transplant- therapeutic classes-focused pharmaceutical delivery systems.	08	L1, L2
Module 2: NANOTECHNOLOGY AND DRUG DELIVERY Introduction, Advantages of Nanostructured Delivery Systems: Localized and Targeted Delivery, Controlled Delivery, Enhanced Circulation Time and Bio distribution, Drug Solubility, Intracellular Drug Delivery, Ability to Cross Biological Membranes, Enhanced Surface Areas. Activation and Targeting of Nanotechnology-Based	08	L1, L2, L3

Drug Delivery Systems (Externally and Internally): Activation and Targeting through PhysicoChemical Stimuli and Drug Targeting through Targeting Molecules. Multifunctional Nanoparticle Systems: Multivalent Strategies and Exploiting Inherent Material Properties.		
Module 3: MATERIALS AND METHODS FOR PREPARATION OF NANOCARRIER SYSTEMS Materials: Introduction, materials used in preparation of nanoparticles as drug carrier systems: polylactic-co-glycolic acid (PLGA), poly lactic acid (PLA), polysaccharides, chitosan, alginate and their pharmaceutical applications, metal nanoparticles, iron oxide nanoparticles, metallic nanoparticles: Ag, Au, and stabilizers. Methods: Polymer precipitation methods: emulsification-solvent evaporation, emulsification-solvent diffusion, salting out method, SLN: preparation methods, Hot homogenization vs Cold homogenization techniques, Encapsulation and Drug release studies.	08	L1, L2, L3, L4
Module 4: SMART POLYMERS AS DRUG CARRIERS Smart polymers: Introduction, smart polymers for drug delivery applications with type of stimuli, phase transition of smart polymers and smart hydrogels, classification of smart polymers: external stimuli (//light) responsive polymers: electrically responsive polymers, magnetically responsive polymers, ultrasonic responsive polymers, light responsive polymers and internal stimuli responsive polymers.	08	L1, L2, L3, L4
Module 5: LIPOSOMES AS DRUG CARRIER Liposomes: Introduction, types of liposomes, materials used in liposome preparation: phospholipids and bilayer additives, Preparation of liposomes, characterization of liposomes, stability of liposomal delivery systems: chemical stability, stability testing, pharmacokinetics, Liposomes uses: fungal treatment, cancer treatment: long circulating liposomes, size and tumor delivery, Doxil (doxorubicin) carrying liposome, Liposome vaccines, immunoliposomes and gene delivery by liposomes.	08	L1, L2, L3
Course Outcome: Students can learn • Basic concepts and applications of Nanotechnology in pharmaceutics. • The applications of Nanotechnology in drug delivery • Materials and methods for preparation of nanocarrier systems • Smart polymers as drug carriers • Liposomes as drug carrier.		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis.		

- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. "Nanotechnology in health care" edited by P.D. Gupta and N. Udupa, first edition, 2011
2. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester; 2002.
3. Biomedical Nanostructures by Kenneth E. Gonsalves and Craig R. Halberstadt, John wiley& sons, inc., publication, 2007.
4. "Nanotechnology in biology and medicine" Methods, Devices, and Applications by Tuan Vo-Dinh, Taylor & Francis Group, LLC, 2007

REFERENCE BOOKS:

1. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester: 2nd ed.; 2001.
2. Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors; Volume Two; Ed. Vladimir M. Mirsky; Springer, Berlin; 2004

ENGINEERING MATERIALS AND SURFACE COATINGS

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VII

Subject Code	17NT743	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:
The objective of this subject is to

- 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.

Modules	Teaching Hours	Revised Bloom's Taxonomy

		(RBT) Level
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.	08	L1, L2, L3
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.	08	L1, L2, L3
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.	08	L1, L2
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);	08	L1, L2, L3

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.	08	L1, L2, L3, L4

Course Outcome:
On completion of this course, students will have comprehension:

- Materials for adhesive applications
- Paints and Lubricants
- Recent developments in nano technology assisted adhesive, paints, and lubricant industries

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1.Adhesive Technology Handbook, 2nd Edition, ISBN: 978-0-8155-1533-3, William Andrew Inc., 2008
2. Adhesion and Adhesives: Science and Technology, Anthony Kinloch, Springer; 1987

REFERENCE BOOKS:

1.A text book of engineering chemistry by Shashi Chawla, DhanpathRai and Co. (PVT) LTD, New Delhi, 2011
2. Electrical Conductive Adhesives with nanotechnologies, Yi Li, Daniel Lu, and C.P. Wong, e-ISBN 978-0-387-88783-8, DOI 10.1007/978-0-387-88783-8, Springer Science+Business Media, LLC 2010

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

FACILITATION, VALIDATION, QC, AND QA [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT744	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			

Course Objective:

As a graduate of this program you will have learned how to do the following:

- To Perform a variety of Quality Control activities including developing QC policies and Standard Operation Procedures
- To Identify and analyze unexpected results during routine analyses and help to provide solutions based on scientific and regulatory considerations by implementing preventive action and corrective actions programs.
- To understand the concept of quality systems and compliance in the regulated industry and the role of quality assurance.
- To understand the use of controlled documentation.
- To know about ISO series of Standards

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: **INTRODUCTION** Validation, Quality control and Quality Assurance: Introduction, history, definition, Validation and Regulatory Affairs: The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP), Good Manufacturing Practice (GMP) & Good Laboratory Practice (GLP). An Introduction to the Basic Concepts of Process Validation & how it Differs from Qualification (IQ, OQ & PQ) Procedures, A Review of Prospective, Concurrent, Retrospective Validation & Revalidation including the use of Statistical Process Control (SPC) Techniques	08	L1, L2
Module 2: **UTILITIES VALIDATION AND ANALYTICAL METHOD VALIDATION** Validation of water system- for production of DM water, distilled water, Validation of Air handling Units- classification of environment (class 100, 10,000, 1,00,000), Performance qualification &	08	L1, L2, L3

parameter of cleanliness such as number of airborne particles, microbes filter integrity test of HEPA filter, air velocity, air flow pattern, no. of air changes, pressure differentials etc. Analytical Method Validation: Recommendation of ICH guideline- Definition of accuracy, precision, linearity, Limit of Detection, Limit of Quantification, range, robustness, ruggedness, specificity, system suitability test. USP requirement of analytical validation- different category of assays.		
Module 3: PLANNING AND VALIDATION ISO 9000 Series & International Harmonization & their effect upon GMP's, Planning & Managing a Validation Program including Change Control, Scale-Up and Post-Approval Changes (SUPAC), Validation of Water & Thermal Systems, including HVAC Facilities & Cleaning Validation. Validation of Active Pharmaceutical Ingredients (APIs) & Aseptic Processes. Validation of Non-Sterile Processes (used in the manufacture of Solids, Liquids, & Semisolid Dosage Forms). Overview of methods of evolution, FDA and ICH guidelines, Development and validation, sample preparation, separations, Minimum detectable amount	08	L1, L2, L3, L4
Module 4: QUALITY STANDARDS ISO 9000 Series of Standards, Quality System, Contract Review, Design Control, Document and Data Control, Preservation and Delivery, Control of Quality Records, Internal Quality Audits, Training, Servicing, Statistical Techniques, ISO-9001-2000, Scope, Normative Reference, Terms and Definitions, Quality Management, System, Documents Requirements, Management's Responsibility, Resource Management, Infrastructure, Product Realization, Measurement, Analysis and Improvement, ISO-14000 - Environmental Management Systems.	08	L1, L2, L3, L4
Module 5: QUALITY CONTROL, QUALITY ASSURANCE AND MANAGEMENT Objectives of QC, Customer Satisfaction, Capability; Terms Relating to Management, Management System, Quality Management System, Quality Policy, Quality Planning, Quality Control, Quality Assurance, Quality Improvement, Continual Improvement, Effectiveness, Efficiency; Relating to Process and Product, Process, Product, Procedure; Terms relating to Characteristics, Quality Characteristics; Terms Relating to Conformity, Non-Conformity, Defect, Preventive Action, Corrective Action, Correction, Rework, Repair, Scrap, Concession, Deviation Permit, Release; Terms Relating to Documentation, Information, Document, Specification, Quality Manual, Quality Plan, Record; Terms Relating of Examination, Objective Evidence, Inspection, Test, Metrological Confirmation. The development of regulatory requirements for validation, Impact Assessment; Failure Mode and Effects Analysis (FMEA), Contamination Control	08	L1, L2, L3

Course Outcome:

- Describe the validation, Quality control, Quality Assurance
- Understand the importance of GAMP and ISO standards
- Explain the implementation of control measures taken in process and product development
- Identify the objectives of Quality control, Quality Assurance and management

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Total Quality Management- Guiding Principle for Application, J. P. Peker, ASTM manual series, Philadelphia.
2. Total Quality Management – The Key to Business Improvement, Champman and Hall, Londan.
3. Quality Assurance Guide by Organisation of Pharmaceutical products of India.
4. ISO 9000 and Total Quality Management – Sadhank. G. Ghosh
5. ISO 9000 Quality Systems Handbook - updated for the ISO 9001:2008 standard, Sixth Edition: Using the standards as a framework for business improvement by David Hoyle, 2009.

REFERENCE BOOKS:

1. R. Nash and Wachter, “Pharmaceutical Process Validation”. Volume 129, Latest Edition. Marcel Dekker Inc., New York.
2. Guidance for Industry, Sterile Drug Products Produced by Aseptic Processing — Current Good Manufacturing Practice-USFDA.
3. www.fda.org
4. US-FDA guideline for bio analytical studies. Dekker Inc., New York
5.Juran’s Quality Handbook, 5th Ed, by J M Juran, A B Godfrey, McGrawHill International Edition
6. Total quality management: strategies and techniques proven at today's most successful companies (Portable Mba Series) by Stephen George and Arnold Weimerskirch, 1998.

SIGNAL AND IMAGE PROCESSING

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT751	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			

Course Objective:

- To understand the basics of biomedical signal and image processing techniques and data acquisition methods
- To design and develop mathematical models for biomedical signal and image processing techniques
- To evaluate and analyse biomedical imaging techniques in nanomedicine

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: INTRODUCTION TO DIGITAL SIGNAL AND IMAGE PROCESSING Signals and Biomedical Signal Processing, Fourier Transform, Filter Design, Image Filtering, Enhancement, and Restoration, Edge Detection and Segmentation of Images, Wavelet Transform	08	L1, L2
Module 2: PROCESSING OF BIOMEDICAL SIGNALS Electrical Activities of Cell, Introduction and Overview, Ion Transport in Biological Cells, Electrical Characteristics of Cell Membranes, Hodgkin-Huxley Model, Electrical Data Acquisition, Some Practical Considerations for Biomedical Electrodes, Electrocardiogram: Introduction and Overview, Electroencephalogram: Introduction and Overview, Electromyogram: Introduction and Overview, Other Biomedical Signals: Introduction and Overview	08	L1, L2, L3
Module 3: PROCESSING OF BIOMEDICAL IMAGES Principles of Computed Tomography: Introduction and Overview, X-Ray Imaging and Computed Tomography: Introduction and Overview, Magnetic Resonance Imaging: Introduction and Overview, Ultrasound Imaging: Introduction and Overview, Positron Emission Tomography: Introduction and Overview, Other Biomedical Imaging Techniques: Introduction and Overview	08	L1, L2, L3, L4
Module 4: NANOTECHNOLOGY IMAGING IN CARDIOLOGY nanotechnology and cardiovascular science, nanotechnology matrices employed for cardiovascular constructs, nanotechnology-based imaging in cardiology, nanotechnology materials for enhanced MRI and ultrasonography-based imaging, specific matrices for	08	L1, L2, L3, L4

nanoparticles used in cardiovascular imaging, nanotechnology for scaffolding platforms and tissue reconstruction, materials and techniques used for nano-scaffold construction, future research directions and conclusion.		
Module 5: NANOIMAGING FOR NANOMEDICINE Applications of Nanoparticles in Medical Imaging, Nanoparticles for Multi-Modality Diagnostic Imaging and Drug Delivery, Atomic Force Microscopy for Nanomedicine, Image-Based High-Content Analysis, Stem Cells and Nanomedicines: A Novel Strategy for Drug Discovery	08	L1, L2, L3

Course Outcome:
After successfully completing this course, students will be able to:

- Understand the fundamentals of biomedical signal and imaging techniques
- Develop mathematical models image processing algorithms and evaluate their performances
- Apply appropriate image processing techniques in cardiology and Nanomedicine

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Kayvan Najarian, Robert Splinter, Biomedical Signal and Image Processing, Second Edition, CRC Press, 2012
2. Information Resources Management Association, Medical Imaging: Concepts, Methodologies, Tools, and Applications, IGI Global, 2016 (Chapter 34) (https://www.safaribooksonline.com/library/view/medical-imaging-concepts /9781522505716/)
3. Raj Bawa, Gerald F. Audette, Israel Rubinstein, Handbook of Clinical Nanomedicine: Nanoparticles, Imaging, Therapy, and Clinical Applications, Pan Stanford, 2016

REFERENCE BOOKS:

1. John L. Semmlow, Benjamin Griffel, Biosignal and Medical Image Processing, Third Edition, CRC Press, 2014
2. Ayman El-Baz, Jasjit S. Suri, Lung Imaging and Computer Aided Diagnosis, CRC Press, 2011

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

NANOTECHNOLOGY FOR ENERGY AND ENVIRONMENT [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT752	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: • To understand the scope of nanotechnology and its materials for the development of energy and environmental issues • To study about nanomaterials and their devices for the improvement of already existing devices and machineries in energy and environmental issues • To understand nano-remediation technologies, and sustainable nanotechnology.			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: NANOTECHNOLOGY FOR SUSTAINABLE ENERGY Nanotechnology for sustainable energy- Energy conversion process, indirect and direct energy conversion-Materials for light emitting diodes-batteries-advanced turbines-catalytic reactors-capacitors-fuel cells. Material structure, Energy carriers, Energy states, Doping. Transport: heat, charge, mass, Thermo-electrics: applications, fundamentals, metrics, materials. Solar thermal: thermoelectric conversion. Photovoltaics: solar resource, p-n junctions, Solar photovoltaics.		08	L1, L2
Module 2: NANOMATERIALS FOR ALTERNATIVE ENERGY Nanomaterials for Fuel Cells and Hydrogen Generation and storage, Nano-structures for efficient solar hydrogen production, Metal Nanoclusters in Hydrogen Storage Applications, Metal Nanoparticles as Electro-catalysts in Fuel Cells, Nanowires as Hydrogen Sensors, Ceramic nanocomposites for alternate energy and environment protection, Applications for Cobalt Nanoparticles and Graphite Carbon-Shells, Nanomaterials for Solar Thermal Energy and Photovoltaic. Semiconductor Nanocrystals and Quantum Dots for Solar Energy Applications.		08	L1, L2, L3
Module 3: NANO-ELECTROMECHANICAL SYSTEMS AND NOVEL MICROFLUIDIC DEVICES		08	L1, L2, L3, L4

Nano engines – driving mechanisms - power generation - microchannel battery - micro heat engine (MHE) fabrication - thermocapillary forces -Thermocapillary pumping (TCP) - piezoelectric membrane. Nanomaterials in Energy Storage Devices: MWNT for Li Ion Batteries, Nanomaterials in Electrodes, Hybrid Nanotubes: Anode Material, Supercapacitor, Battery Electrodes.		
Module 4: NANO REMEDIATION TECHNOLOGIES Nanomaterials-Remediation: Nano Membranes, Nano Meshes, Nano Fibres, Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Carbon Nano Tubes, Bio Polymers, Single Enzyme Nano particles, Bio Metallic Iron Nano Particles, Nano Semi-Conductors, Photo catalysis, Nano-sensors. Nano Remediation Technologies: Environmental Nano Remediation Technology - Thermal, Physico-Chemical and Biological Methods, Nano Filtration for treatment of waste – removal of organics & inorganics and pathogens, Nanotechnology for water remediation and purification. Treatment of hi-tech industrial waste waters using nano particles/ modified structures/devices. Environmental Benefits of nanomaterials.	08	L1, L2, L3, L4
Module 5: SUSTAINABLE NANOTECHNOLOGY Application of industrial ecology to nanotechnology, Fate of nanomaterials in environment, environmental life cycle of nano materials, environmental and health impacts of nano materials, toxicological threats, eco-toxicology, exposure to nano particles – biological damage, threat posed by nano materials to humans, Environmental reconnaissance and surveillance. Corporate social responsibility for nanotechnology, Nano materials in future - implications.	08	L1, L2, L3
Course Outcome: Students can • understand the scope of nanotechnology and its materials for the development of energy and environmental issues • study about nanomaterials and their devices for the improvement of already existing devices and machineries in energy and environmental issues • Understand nano-remediation technologies, and sustainable nanotechnology.		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module.		

• Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, (1986). 2. Martin A Green, Solar cells: Operating principles, technology and system applications, Prentice Hall Inc, Englewood Cliffs, NJ, USA, (1981). 3. Hoogers, Fuel cell technology handbook. CRC Press, (2003). 4. Nanotechnlogy: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008.
REFERENCE BOOKS: 1. Vielstich, Handbook of fuel cells: Fuel cell technology and applications, Wiley, CRC Press, (2003). 2. Junhui He, Nanomaterials in Energy and Environmental Applications, (2016), CRC Press 3. Nanotechnologies, Hazards and Resource efficiency by M. Steinfeldt, Avon Gleich, U. Petschow, R. Haum. Springer, 2007.

3D PRINTING TECHNOLOGY [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Subject Code	17NT753	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: The students should be made to: • Understand the basic concepts and nuances of 3D Printing Technology			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: **INTRODUCTION** Introduction; Design considerations – Material, Size, Resolution, Process; Modelling and viewing - 3D; Scanning; Model preparation – Digital; Slicing; Software; File formats		08	L1, L2
Module 2: **PRINCIPLE** Processes – Extrusion, Wire, Granular, Lamination, Photo-		08	L1, L2, L3

polymerisation; Materials - Paper, Plastics, Metals, Ceramics, Glass, Wood, Fibre, Sand, Biological Tissues, Hydrogels, Graphene; Material Selection - Processes, applications, limitations.		
Module 3: INKJET TECHNOLOGY Printer - Working Principle, Positioning System, Print-head, Print-bed, Frames, Motion control; Print-head Considerations – Continuous Inkjet, Thermal Inkjet, Piezoelectric Drop-On-Demand; Material Formulation for jetting; Liquid based fabrication – Continousjet, Mulitjet; Powder based fabrication – Colour-jet.	08	L1, L2, L3, L4
Module 4: LASER TECHNOLOGY Light Sources – Types, Characteristics; Optics – Deflection, Modulation; Material feeding and flow – Liquid, powder; Printing machines – Types, Working Principle, Build Platform, Print-bed Movement, Support structures.	08	L1, L2, L3, L4
Module 5: INDUSTRIAL APPLICATIONS Product Models, manufacturing – Printed electronics, Biopolymers, Packaging, Healthcare, Food, Medical, Biotechnology, Displays; Opensource; Future trends.	08	L1, L2, L3
Course Outcome: Upon completion of the course, the student should be able to: • Learn 3D printing workflow • Understand the basic types of 3D Printing, materials used and their applications • Select appropriate method for designing and modelling applications		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
TEXT BOOKS: 1. Ian M. Hutchings, Graham D. Martin, “Inkjet Technology for Digital Fabrication”, John Wiley & Sons, 2013. 2. Christopher Barnatt, “3D Printing: The Next Industrial Revolution”, CreateSpace Independent Publishing Platform, 2013.		
REFERENCE BOOKS: 1. Ibrahim Zeid, “Mastering CAD CAM” Tata McGraw-Hill Publishing Co.2007 2. Joan Horvath, “Mastering 3D Printing”, APress, 2014		

3. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", second edition, World Scientific Publishers, 2010.

NANO TOXICOLOGY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VII

Subject Code	17NT754	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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, Education Opportunities - Human Resources for	08	L1, L2, L3

Nanotechnology		
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3
Course Outcome: • To learn the basic concepts of nanobiotoxicology. • To understand nanomaterial pollution, public perceptions & education • To study the human exposure to nanosized materials • To do risk economic impacts of nanotechnology • To study ethics laws and regulations of nanomaterials and their toxicity		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
TEXT BOOKS:		

1. Yuliang Zhao and Hari Singh Nalwa, 'Nanotoxicology: Interactions of Nanomaterials with Biological Systems, American Scientific Publishers, 2007
2. "Nanotoxicology - Interactions of Nanomaterials with Biological Systems", Ed Yuliang Zhao and Hari Singh Nalwa, June 2006
3. Mihail C. Roco and William Sims Bainbridge, "Nanotechnology: Societal Implications II – Individual Perspectives", Springer Publishers, Sponsored by National Science Foundation, ISBN-10 1-4020-4658-8.
4. "Nanotechnology in health care" edited by P.D. gupta and N. Udupa.

REFERENCE BOOKS:

1. E P. Widmaier, H. Raff, K.T. Strang, Vander, Sherman and Luciano, 'Human Physiology: The Mechanisms of Body. Functions', 9th edition, McGraw Hill, New York, 2004
2. Gunter Oberdörster, Eva Oberdorster and Jan Oberdorster, Environmental Health Perspectives, Volume 113 Number 7, July 2005
3. D. Drobne, 'Nanotoxicology for safe and Sustainable Nanotechnology', Nanotoxicology for safe and sustainable Nanotechnology , 58, pp. 471-478, December 2007
4. Monteiro-Riv, 'Nanotoxicology: Characterization, Dosing and Health Effects', Informa Healthcare publishers, 2007
5. A Reference handbook of nanotoxicology by M. Zafar Nyamadzi

NANO - COMPOSITES, DEVICE FABRICATION, AND CHARACTERIZATION LAB

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VII

Laboratory Code	17NTL76	IA Marks	40
Number of Lecture Hours/Week	01Hr Instruction + 02 Hrs Laboratory	Exam Marks	60
		Exam Hours	03

CREDIT - 02

Course Objective:

- To study about the nanomaterials, and their composite preparation
- To learn about the device fabrication and designing by using nanomaterials and nanocomposites.
- To characterize the nanomaterials

List of Experiments	Revised Bloom's Taxonomy (RBT) Level
1. Dye Sensitised Solar cell fabrication	L5,L6
2. Gas sensor fabrication	L5,L6
3. Bio-chemical sensor fabrication	L5,L6
4. Fabrication of nanomaterial based super capacitor	L5,L6
5. Preparation of ceramic based nanocomposites	L5,L6
6. Preparation of metal-biopolymer nanocomposites	L2,L3,L4

7. Preparation of metal-polymer nanocomposites	L2,L3,L4
8. Calculate the wear rate from wear track depth 2D images.	L2,L3,L4
9. Calculation of the Area under the curve for a specified element/compound for a Raman data by filling the area under curve using origin Pro.	L2,L3,L4
10. Analyse of the amount of elastic and plastic deformation from a Nanohardness test (NHT) data using origin pro.	L5,L6
11. 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).	L5,L6
12. 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.	L2,L3,L4
13. 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.	L2,L3,L4
14. 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.	L2,L3,L4
15. Get the XRD peaks from the given ASCII file and find the FWHM and calculate interplanar distance "d" using Bragg's equation.	L2,L3,L4
Course Outcome: Students can • Prepare nanomaterials, and their composites. • Prepare nanotechnology based devices • Characterize the nanomaterials	
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.	
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.	
REFERENCE BOOKS: 1. Lab manual	

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

MEMS SIMULATIONS LAB [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VII			
Laboratory Code	17NTL77	IA Marks	40
Number of Lecture Hours/Week	01Hr Tutorial + 02 Hrs Laboratory	Exam Marks	60
		Exam Hours	03
CREDIT - 02			

Course Objective:

- To understand the simulation programmes for the MEMS characteristics
- To study about MEMS devices and calculations by using MEMSolver software

List of Experiments	Revised Bloom's Taxonomy (RBT) Level
1. Calculation & Simulation of burst pressure, non-linearity & plot graph for sensitivity for Piezoresitive pressure sensor with a square diaphragm.	L2,L4,L5
2. Calculation & Simulation of burst pressure, non-linearity & plot graph for sensitivity for Piezoresitive pressure sensor with a round diaphragm.	L2,L3,L4
3. Calculation & Simulation ofburst pressure, non-linearity & plot graph for sensitivity for Piezoresitive pressure sensor with a rectangular diaphragm.	L2,L3,L4
4. Calculation & Simulation of maximum acceleration, maximum sensitivity, non-linearity & plot graph for acceleration V/S displacement of capacitive accelerometer for static signal.	L5,L6
5. Calculation & Simulation of maximum acceleration, maximum displacement & plot graph for acceleration V/S displacement of capacitive accelerometer for step signal.	L5,L6
6. Calculation & Simulation of time duration of pulse & plot graph for acceleration V/S time of capacitive accelerometer for pulse signal.	L2,L3,L4
7. Calculation & Simulation of output current, output voltage, piezoelectric capacitance & plot graph for output V/S frequency of piezoelectric accelerometer under longitudinal load.	L5,L6
8. Calculation & Simulation of output current, output voltage, piezoelectric capacitance & plot graph for output V/S frequency of thin film based piezoelectric accelerometer.	L2,L3,L4
9. Calculation & Simulation of pull in voltage, actuation force, balanced displacement & plot graph for force V/S displacement of parallel plate actuator for normal motion.	L2,L3,L4
10. Calculation & Simulation of pull in voltage, angular displacement, actuation torque & plot graph for voltage V/S tilt angle of torsion bar actuator for torsion motion.	L5,L6
11. Calculation & Simulation of balanced displacement, actuation	L5,L6

force, normal spring constant & plot graph for voltage V/S displacement of comb drive actuator for lateral motion.	
12. Calculation & Simulation of tip deflection, tip force & plot graph for deflection V/S film thickness of cantilever based bimetallic thermal actuator.	L2,L3,L4
13. Calculation & Simulation of deflection, tip force & plot graph for deflection V/S beam length of thermal bimorph actuator	L2,L3,L4
14. Calculation & Simulation of maximum deflection, response time, maximum temperature change & plot graph for transient response of thermal bent beam actuator.	L2,L3,L4
15. Calculation & Simulation of actuator displacement, actuator force, electric field strength & plot graph for actuator force of longitudinal piezoelectric actuator.	L2,L3,L4
16. Calculation & Simulation of actuator displacement, actuator force, electric field strength & plot graph for actuator displacement of transverse piezoelectric actuator.	L2,L3,L4
Course Outcome: Students can • understand the simulation programmes for the MEMS characteristics • study about MEMS devices and calculations by using MEMSolver software	
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.	
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 16 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.	
REFERENCE BOOKS: 1. Lab manual	

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Core Subjects

NANO-ELECTRONICS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VIII			
Subject Code	17NT81	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT – 04			
Course Objective: • To understand the basic concepts of nano-electronics • To learn the techniques which are used for develop devices which are developed by nanotechnology.			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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		10	L1, L2
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.		10	L1, L2, L3
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.		10	L1, L2, L3, L4
Module 4: **NANO ELECTRONICS WITH TUNNELING DEVICES** Tunnelling Diode, Resonant Tunnelling Diode (RTD), Three Terminal		10	L1, L2, L3, L4

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	10	L1, L2, L3

Course Outcome:

- Students will understand how to design the electronics circuits to work at nanoscale level
- Students can learn how I-V characteristics and other electronic properties may change at nanoscale level.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Niraj K. Jha. (2010) Deming Chen, Nanoelectronic Circuit Design, Springer.
2. Goser Karl and Peter Glosekotter. (2004) Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, Springer.
3. Shareefraza J. Ukkund, Nano-Electronics and Quantum Computation, LAP-Lambert Academic Publishing, Mauritius, 2018, ISBN: 978-613-9-81812-9
4. Lundstrom, Mark, Guo, Jing, Nanoscale Transistors: Device Physics, Modelling and Simulation, Springer, 2006.

REFERENCE BOOKS:

1. Gregory Timp. (2008) Nanotechnology, AIP Press.
2. Colm Durkan. (2007) Current at the Nanoscale, Imperial College Press.
3. S. Dutta. (2005) Quantum Transport: Atom to Transistor, Cambridge University Press

BIO-NANOTECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
Syllabus effective from 2017-2018
Choice Based Credit System (CBCS)
B.E. Nano Technology

Course: B.E. / Nano Technology Semester: VIII			
Subject Code	17NT82	IA Marks	40
Number of Lecture Hours Per Week	04	Exam Marks	60
Total Number of Lecture Hours	50	Exam Hours	03
CREDIT – 04			

Course Objective:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	10	L1, L2
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.	10	L1, L2, L3
Module 3: **BIO-NANOMACHINES**	10	L1, L2, L3, L4

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.	10	L1, L2, L3, L4
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	10	L1, L2, L3
Course Outcome: Students can • To learn the basics of Nanobiotechnology, the devices of Nanobiotechnology and their applications to the different fields. • To understand and fabricate the nanostructures and nanocontainers for several applications		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from		

each module.
TEXT BOOKS: 1. David S. Goodsell, Bionanoechnology-lessons from nature, Wiley India Pvt. Ltd., 2013, ISBN: 978-81-265-3836-2 2. Applications of Bio-Nanotechnology, Dr. Prasad P. Embrandiri, LAP-Lambert Academic Publishing, Mauritius, 2018, ISBN: 978-613-9-81794-8 Niemeyer and Mirkin ed. Nanobiotechnology: concepts, applications & perspectives, 3. Jain, KK. Nanobiotechnology in molecular diagnostics: current techniques and Applications
REFERENCE BOOKS: 1. Bionanotechnology - Global Prospects by David E. Reisner, Taylor & Francis Group, LLC, 2009 2. Bio-Applications of Nanoparticles BY Warren C.W. Chan, Springer Science, Business Media, 2007 3. Applications of nanoparticles in biology and medicine by Salata O.V., Journal of Nanobiotechnology, 2:3, 2004.

Professional Elective Subjects

NANO-PHOTONICS [As per Choice Based Credit System (CBCS) scheme] (Effective from the academic year 2017-2018) Course: B.E. / Nano Technology Semester: VIII			
Subject Code	17NT831	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03
CREDIT – 03			
Course Objective: • To understand the basic principles of Photonics and its importance • To study the nano-photonics its fabrication and applications			
Modules		Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module 1: INTRODUCTION TO OPTICS, PHOTONICS AND NANO-PHOTONICS Different quantities associated with light; Properties of Light; Reflection; Refraction; Interference & Diffraction; Absorption & Scattering, Properties of materials with respect to reflection, refraction, absorption and transmission of light. Photonics: Introduction, history; Classical optics, and modern optics; Applications of photonics; Emerging fields of photonics: light sources, transmission media, amplifiers, modulation, photonic		08	L1, L2

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.	08	L1, L2, L3
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.	08	L1, L2, L3, L4
Module 4: FUNDAMENTALS OF NANO-PHOTONIC FABRICATION 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.	08	L1, L2, L3, L4
Module 5: FUNDAMENTALS OF NANO-PHOTONIC SYSTEMS Introduction – 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 – Hierarchy in nano-photonics and its system fundamentals, Hierarchical Memory Retrieval, Analysis and Synthesis of Hierarchy in Nano-photonics, Hierarchy Plus Localized Energy Dissipation: Traceable Memory.	08	L1, L2, L3
Course Outcome: Students can • understand the basic principles of Photonics and its importance • Study the nano-photonics its fabrication and applications		
Graduate Attributes (as per NBA):		

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. Principals of Nanophotonics (Optics and Optoelectronics), M. Ohtsu, K. Kobayashi, T. Kawazoe and T. Yatsui, University of Tokyo,Japan,2003
2. Nanophotonics, P N Prasad, John Wiley & Sons (2004)
3. Photonic Crystals: Towards Nanoscale Photonic Devices; Jean Michel Lourtioz, Springer; ISBN 354024431X3.

REFERENCE BOOKS:

1. NanoBiophotoics, H.Masuhara,SKawata and F TokungaElsevier Science 2007
2. Fundamentals of Photonics, BEA Saleh and AC Teich, John Wiley and Sons,NewYork,1993
3. Introduction to Biophotonics, P.N.Prasad, John Wiley and Sons, 2003.
4. Fundamentals of Photonic Crystal Fibres; Fredric Zolla- Imperial College Press. ISBN 1860945074.

NANOMEDICINE AND BIOMEDICAL IMAGING

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VIII

Subject Code	17NT832	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:

- To learn the new opportunities of nanotechnology in biomedical industries, for bio-imaging with several Nanomaterials.
- To understand and design the nanostructures nanospheres and nanoparticles for biomedical industries, pharmaceutical and cosmetic industries.

Modules	Teaching	Revised

	Hours	Bloom's Taxonomy (RBT) Level
Module 1: TECHNIQUES IN BIOMEDICAL IMAGING AND NANOSTRUCTURING Immuno Fluorescent Biomarker Imaging- Immuno gold labelling- Nanoprobes BioPhotonics - Diagnostic Biosensors- Catalyst-Functionalized Metallic Nanoparticles and their Applications in Colorimetric Sensing- Dip stick Tests- Nanoparticles as Catalysts for Signal Generation and Amplification- Iron Oxide Nanoparticles in Magnetic Resonance Imaging- Optical nanoparticles sensors for quantitative intracellular imaging. Cancer imaging- Nanophotonics. Design aspects of Nanostructures-Lithographic techniques-Nanoimprinting- Near Field Optical Methods of fabrication- Nano-polishing with diamond and Etching of nanostructures-Nanoindendation-Focused Ion beam.	08	L1, L2
Module 2: NANOPARTICLES IN THERAPEUTICS Nanorobotics, gold and silver nanoparticles for cancer therapy, chemotherapy, Immunotherapy, Vaccine immunotherapy, Radiotherapy, thermotherapy, photo dynamic therapy, textiles and wound care products, Implantable materials for vascular interventions, active implantable devices and bionics, Implantable materials for orthopaedic and dentistry. NANOSURGERY Introduction to Surgery, Impact of nanotechnology on surgery: Surgical blades and suture needles. Femto-second lasers, Nanoshell particles, minimally invasive surgery using catheters, optical tweezers, Bio-molecular motors, Biocompatibilities, molecular robots (utility fog).	08	L1, L2, L3
Module 3: NANOBIOMECHANICS Nano-materials in bone substitutes & Dentistry, Biosensors-Natural nanocomposite systems as spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Polymeric nanofibres – Implications in Neuro science, tissue engineering and cancer therapy. Polyelectrolyte multilayers-coated colloids- smart capsules. Colloids and colloids assembly of bio nanotechnology. Micro emulsions in nanotechnology.	08	L1, L2, L3, L4
Module 4: NANOPARTICLES IN DIAGNOSIS Nanochips (Gene chip and protein chip), ultrasensitive biobarcode, Nanochip for HIV detection. Transport and toxicity properties of semiconductor nano crystals, Imaging applications. Nano Bioactive glasses-preparation methods, nanobioactive glass powders and properties, biomed applications. Gene therapy and Nanotechnology: Gene therapy using nanoparticles; stem cell	08	L1, L2, L3, L4

therapy. Nanostructured materials for biological sensing. Nanoporous membranes.		
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, different types of drug loading, Nanoscale drug delivery devices, Nano vectors for gene therapy, mechanism of drug targeting, drug delivery carriers, Biodegradable polymers, Nanoparticulate delivery systems, solid polymer nanoparticles, nano-particle mediated drug delivery to solid tumors, colloidal nanosilver particles as an effective nano antibiotic.	08	L1, L2, L3

Course Outcome:
Students can

- learn the new opportunities of nanotechnology in biomedical industries, for bio-imaging with several Nanomaterials.
- understand and design the nanostructures nanospheres and nanoparticles for biomedical industries, pharmaceutical and cosmetic industries.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full Question consisting of 20 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

1. M. Reza Mozafari (2007) Nanomaterials and Nanosystems for Biomedical Applications, Springer.
2. VinodLabhasetwar and Diandra L. Leslie, “Biomedical Applications of nanotechnology”, A John Willy& son Inc,NJ, USA, 2007 .
3. J. B Park, “Biomaterials Science and Engineering”, Plenum Press, New York, 1984.
4. T. Pradeep, “Nano: The essentials”, McGrew – Hill, 2007
5. J. J. Davis, Dekker, “Encyclopedia of Nanoscience and nanotechnology”

REFERENCE BOOKS:

1. Natalie P. Praetories and Tarun K. Mandal, Recent Patents on Drug Delivery& Formulation Y. Lu, S.C. Chen, Advanced Drug Delivery Reviews.
2. P.P. Simeonova, N. Opopol and M.I. Luster, “Nanotechnology - Toxicological Issues and EnvironmentalSafety”, Springer 2006.
3. G.L Hornyak, J Dutta, H.Tibbals and A.K.Rao, Introduction to NanoScience, Taylor & Francis Group, CRC press, 2008.

4. Miyawaki, J.; et.al Toxicity of Single-Walled Carbon Nanohorns. ACS Nano 2 (213–226) 200
5. Hutchison, J. E. Green Nanoscience: A Proactive Approach to Advancing Applications and Reducing Implications of Nanotechnology. ACS Nano 2, (395–402) 2008.
6. Mo-Tao Zhu et.al Comparative study of pulmonary responses to nano- and submicron-size ferricoxide in rats Toxicology, 21 (102-111) 2008.
7. Dracy J. Gentleman, Nano and Environment: Boon or Bane? Environmental Science and technology, 43 (5), P1239, 2009.

MECHANICAL OPERATIONS

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VIII

Subject Code	17NT833	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:

- 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.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2
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;	08	L1, L2, L3

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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3
Course Outcome: Students can understand: • The particle size analysis by different models and methods • Different types of flow measurement methods and techniques. • The filtration methods, classification, importance and applications • The agitation and mixing aspects and applications. • The sampling, storing of solid samples.		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		
TEXT BOOKS: 1. Unit Operations of Chemical Engineering, McCabe W.L., et.al., V Edn., McGraw Hill		

International, New york, 2000.
2. Mechanical Operations, Shareefraza J. Ukkund, Dr. Shrinivasa D. Mayya, Dr. Prasad Puthiyillam, LAP-Lambert Academic Publishers, Mauritius, 2018, ISBN: 978-613-9-82579-0
3. Introduction to Chemical Engineering, Badger, W.L. and Banchero J. T., 3rd Edition, McGraw Hill International Edition, Singapore, 1999.
4. Coulson and Richardson's Chemical Engineering Vol. 2 Particle Technology and Separation Processes, Coulson J.M. and Richardson J.F., 4th Edition, Asian Books Pvt. Ltd, New Delhi, 1998.

REFERENCE BOOKS:

1. Unit Operations, Brown. G.G., 1st Edition, CBS Publishers, New Delhi, 1995.
2. Perry's Chemical Engineers' Handbook, Perry R and Green W.D., 1st Edition, McGraw Hill, International, New York, 2000.
3. Principles of Unit Operations, Foust A. S. et.al., 3rd Edition, John Wiley and Sons, New York,1977.

GREEN NANOTECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]
(Effective from the academic year 2017-2018)
Course: B.E. / Nano Technology
Semester: VIII

Subject Code	17NT834	IA Marks	40
Number of Lecture Hours Per Week	03	Exam Marks	60
Total Number of Lecture Hours	40	Exam Hours	03

CREDIT – 03

Course Objective:

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	08	L1, L2

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.	08	L1, L2, L3
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3, L4
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.	08	L1, L2, L3
Course Outcome: Students can • understand the eco-friendly nature of nanotechnology and the Nanomaterials • study nanotechnology and nanodevices which are environmental friendly		
Graduate Attributes (as per NBA): • Engineering Knowledge. • Problem Analysis. • Design / development of solutions (partly). • Interpretation of data.		
Question paper pattern: • The question paper will have ten questions. • Each full Question consisting of 20 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module.		

• The students will have to answer 5 full questions, selecting one full question from each module.
TEXT BOOKS: 1. David Allen T. and David R. Shonnard, "Green engineering", Prentice Hall NJ, 2002. 2. David Dornfeld," Green manufacturing fundamental and applications" Prentice hall, 2002.
REFERENCE BOOKS: 1. Sammy Shinga G., "Green electronics design and manufacturing", Prince Publications, 2008. 2. James Clark, "Green chemistry", Blackwell publishing, 2008. 3. Paulo Davim," Sustainable manufacturing", Wiley publications 2010. 4. Frank Kreith, George Tchobanoglous, "Solid waste management", McGraw Hill, 2002. 5. Stevens S., "Green plastics", Princeton University press, 2002. 6. Robert Ayres U., "A Handbook of Industrial Ecology", Edward Elgar publishing, 2002.