CENTRE FOR NANOTECHNOLOGY

AU COLLEGE OF ENGINEERING

M TECH. (N T): SCHEME OF INSTRUCTION AND EXAMINATION

(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Program Educational Objectives (PEOs):

Based on the mission of the centre, the program specific objectives are formulated as

PEO1. To provide basic and advanced knowledge regarding nanotechnology. Be employed in fields of engineering such as research, development, applications, testing, processing, analyzing and technical sales or service as an engineering technologist.

PEO2. Train the learners with mathematical and logical tools to use sound discretion in evaluation and judgement of contemporary scientific literature

PEO3. Train the learners to handle complex equipment, perform advanced analyses and communicate with precaution, precision, confidence and integrity

PEO4. Instill the leaners with confidence to work independently as well as the competence to work as a team player to achieve the defined goals

PEO5. Train leaners to find Nanotechnology based solutions for the benefit of the society that are technically sound, environmentally compatible, economically viable, sustainable, and commercially worthwhile.

Program Outcomes (POs):

PO1. To strengthen the application of fundamental knowledge in Science, Engineering and Technology for the benefit of mankind.

PO2. To enhance the technical competence of identifying, analyzing and creating appropriate engineering solutions.

PO3. To provide demand-based training to meet the graduates readily employable by the industries.

PO4. To create opportunities for the students to take on research projects for solving the problems of the future.

PO5. To cultivate the habit of lifelong learning for successful career and life.

PO6. To inculcate qualities of team work and leadership for creating future leaders of the nation.

PO7. To impart awareness of social responsibilities for becoming a responsible citizen.

Program Specific Outcomes (PSOs):

A student who has undergone M.Tech. programme in Nanotechnology will:

PSO1. Have an ability to evaluate and analyze problems related to nanotechnology and be able to synthesize the domain knowledge and incorporate the principles in the state of art systems for further enrichment.

PSO2. Identify the type of material, polymer or structure that is best suited to applications in different fields of engineering. Handle scientific equipment, characterize the given nanomaterials and analyze the data

PSO3. Demonstrate leadership and entrepreneurship in the translation of the research from lab to industry. Display highest order of professional ethics, honesty and integrity.

I – SEMESTER

Code No.	Course title	Scheme of Instruction			Scheme of Examination			Total	Credits
		Lec.	Tut.	Total	Exam. Duration	Theory /Lab./Viva	Sess.		
NT 101	Core subject 1: **Quantum Physics & Quantum Chemistry**	4	--	4	3	70	30	100	4
NT 102	Core subject 2: **Introduction to Nanotechnology**	4	--	4	3	70	30	100	4
NT 103	Core subject 3: **Electronic Devices and Circuits**	4	--	4	3	70	30	100	4
NT 104	Core subject 4: **Carbon Nanotube Science and Technology**	4	--	4	3	70	30	100	4
NT 105	**Elective Subject - 1** **1. Chemistry of Nanomaterials** **2. Green Manufacturing Technology** **3. Nanoscale Magnetic Materials and Devises** **4. Micro Nano Mechanics** **5. Nanoionics: Concepts and Technological Applications** **6. Nano CMOS Circuit and Physical Design** **7. Quantum Mechanics for Nanotechnology** **8. Advanced Finite Element Analysis**	4	--	4	3	70	30	100	4
NT 106	**Elective Subject - 2** 1. **Thin Film Science and Technology** **2. Statistical Thermodynamics for Nanosystems** **3. Spectroscopic Techniques for Nanomaterials** **4. Bionanotechnology** **5. Nano Materials For Energy and Environment** **6. Micro/ Nano Colloids and Emulsions** **7. Nanoscale Integrated Computing** **8. Computational Fluid Dynamics**	4	--	4	3	70	30	100	4
NT 107	Lab 1: **Synthesis of Nanomaterials**	--	3	3	Viva-Voce	50	50	100	2
NT 108	Lab 2: **Computer Aided modeling and Simulation**		3	3	Viva-Voce	50	50	100	2

Total	24	6	30		520	280	800	28

II – SEMESTER

Code No.	Course title	Scheme of Instruction			Scheme of Examination			Total	Credits
		Lec.	Tut.	Total	Duration of Exam. (hrs)	Theory Lab./ Viva	Sess.		
NT 201	Core subject 1: **Characterization of Materials**	4	--	4	3	70	30	100	4
NT 202	Core subject 2: **Micro and Nano Fabrication**	4	--	4	3	70	30	100	4
NT 203	Core subject 3: **Polymer Nanocomposites**	4	--	4	3	70	30	100	4
NT 204	Core subject 4: **Nanofluids Science and Technology**	4	--	4	3	70	30	100	4
NT 205	**Elective Subject - 3** **1. Nanolithography and Devise Fabrication** 2. **Nanotoxicology** **3. Nanotechnology Business Applications and Commercialization** **4. Social Impacts of Nanotechnology** **5. Fuel Cell Technology** **6. Computational Nanotechnology** **7. Nanomaterials for Solar Energy and Photovoltaics** **8. Advanced Mechanics of Composite Materials**	4	--	4	3	70	30	100	4
NT 206	**Elective Subject - 4** **1. Research Methodology – Engineering and Management Studies** **2. Advanced Optimization Techniques** 3. **Computational Methods in Fluid Flow and Heat Transfer** **4. Nanotechnology in Health Care** **5. Nanotechnology Intellectual Property Rights** **6. Nanopollution and e-**	4	--	4	3	70	30	100	4

	Waste Management **7. Industrial Nanotechnology** **8. Nanotechnology in 1Polymers**								
NT 207	Lab 1: **Characterization of Nanomaterials and Nano Structures**	--	3	3	Viva-Voce	50	50	100	2
NT 208	**Seminar**		3	3	Viva-Voce	50	50	100	2
Total		**24**	**6**	**30**		**520**	**280**	**800**	**28**

III – SEMESTER

Code No	**Course title**	**Scheme of Examination**	**Total Marks**	**Credits**
NT 301	Dissertation (Preliminary)	Viva-voce	**100**	**10**

IV – SEMESTER

Code No	**Course title**	**Scheme of Examination**	**Total Marks**	**Credits**
NT 401	Dissertation (Final)	Viva-voce	**100**	**14**

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CORE SYLLABUS
FIRST SEMESTER
NT 101 QUANTUM PHYSICS & QUANTUM CHEMISTRY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To achieve an understanding of the theory of quantum science, and an ability to apply the quantum theory to important physical systems.
2. To acquire the knowledge of basic sciences required to understand the fundamentals of nanomaterials
3. To get familiarize with the basic concepts of photonics and thermal properties of nanomaterials.
4. To acquire the knowledge of electronic, optical and magnetic properties of nanomaterials.

Course Outcomes

1. Able to know the world of quantum physics and chemistry & solve the quantum mechanical problem.
2. Gain knowledge on crystalline physics & its practical application.
3. Can estimate the behavior of atoms in electric, magnetic and electromagnetic field.

BASIC PHYSICAL AND QUANTUM ASPECTS OF CHEMISTRY

Periodic table, surface energy of nanostructure materials, thermodynamic laws. Helm Holtz hermalequation, Gibbs free energy. Basic postulates and Theorem of quantum mechanics. Quantum mechanics of particle in box, cone dimensional harmonic oscillator, Rigid Rotator and Hydrogen-like atoms. Orbitals and shapes of orbital. Theories of chemical bonding. Valence bond theory. Molecular orbital theory and LCAO approximation. MO theory of H_2 and H^{2+} ion. Electronic structure. Linear combination of atomic structure.

CRYSTAL STRUCTURE AND SIZE EFFECTS ON STRUCTURE AND MORPHOLOGY OF NANOPARTICLES

Simple crystal structures- Sodium chloride structure. Cesium Chloride structure. Hexagonal close-packed structure. Hexagonal zinc sulfide (Wurtzite) structure. Diffraction of waves by crystals-Bragg law, Scattered wave amplitude-Fourier analysis, Reciprocal lattice vectors; Brillounins zone-reciprocal lattice to sc lattice, reciprocal lattice to BCC lattice, Reciprocal lattice to FCC lattice point defects-lattice vacancies; diffusion metals; color centers-f centers, other centers in alkali halides. Fundamental Properties - Size Effects on Structure and Morphology of Free or Supported Nanoparticles - Size and Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress - Effect on the Lattice Parameter - Effect on the Phonon Density of States - Nanoparticle Morphology - Equilibrium Shape of a Macroscopic Crystal - Equilibrium Shape of Nanometric Crystals - Morphology of Supported Particles.

PHONON DYNAMICS AND THERMAL PROPERTIES

Overview of Reciprocal lattice, Brillouin zone – Crystals with monoatomic basis – Two atoms per primitive basis – Quantization of Elastic waves – Phonon momentum – Elastic properties – Phonon Heat Capacity – Planck distribution – Density of states – Einstein’s model of Density of states - Thermal expansion – Heat conduction by Phonons – Vibrational and Thermal properties of Nanostructures .Vibration of Monatomic lattices- First Brillouin zone, group velocity. Long wave length or continuum limit, derivation of force constants from experiment. Lattice with two atoms per primitive cell. Quantization of lattice vibrations. Phonon momentum. Inelastic scattering of neurons by phonons.

ELECTRONIC, OPTICAL AND MAGNETIC PROPERTIES OF MATERIALS:

Free electron theory of metals, Band theory of solids, Bloch theorem, Kroning-Penne model, Metals and Insulators, Semiconductors: Classification, Transport properties, Size and Dimensionality effects, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects. Optical Properties, Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence. Magnetic Materials: Basic Magnetic Phenomena; Diamagnetism, Paramagnetism, Ferromagnetism, Ferrimagnetism, Anti-ferromagnetism, Some examples of these materials and their applications, RKKY Interactions, Ferrofluids, Introduction to superconductivity; London Equation and Josephson effect.

References

1. Introduction to solid state physics – C Kittel, Fifth edition
2. Elements of solid state physics – JP Srivastava, 2001 published.
3. Introduction of quantum chemistry – AK Chandra, 4th edition
4. Quantum Chemistry - Eyring, Walter and Kimball.
5. C. N. Rao, A. Muller, A. K. Cheetham ,―Nanomaterials chemistry‖, Wiley-VCH (2007).
6. P.M. Mathews and K. Venkatesan, Quantum Mechanics, Tata McGraw Hill, Second Edition (2010).
7. Ajoy Ghatak and S. Lokanathan, Quantum Mechanics, Macmillan, Fifth Edition (2009).
8. J. M. Ziman, Principles of the Theory of Solids, Cambridge University Press (2011).
9. N. W. Ashcroft, N. D. Mermin, Solid State Physics, Brooks/Cole Publishers (2003).
10. H. Ibach, Harald Luth, Solid-State Physics: An Introduction to Principles of Materials Science, Springer (2003).
11. Quantum Physics – A. Ghatak
12. Quantum Mechanics - Bransden and Joachen
13. Quantum wells, Wires & Dots,: Theoretical & Computational Physics of Semiconductors Nanostuructures, Paul Harrison
14. Principles of Quantum Mechanics 2nd ed. - R. Shankar
15. Thermodynamics and Statistical Mechanics - A N Tikhonov, Peter T Landberg, Peter Theodore

Web links

1. https://archive.org/details/IntroductionToSolidStatePhysics
2. http://as.wiley.com/WileyCDA/WileyTitle/productCd-EHEP000803.html
3. http://www.physics.ucla.edu/~nayak/solid_state.pdf
4. http://folk.uio.no/yurig/fys448/f448pdf.pdf
5. http://www-thphys.physics.ox.ac.uk/people/SteveSimon/condmat2012/LectureNotes2012.pdf

CORE SYLLABUS
FIRST SEMESTER
NT 102 INTRODUCTION TO NANOTECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To acquire the knowledge of importance of Nano-technology, Emergence of Nano-Technlogy, synthesis approaches of nanomaterials and challenges in Nano Technology.
2. To gain the understanding of properties of low dimensional system.
3. To understand the basic sciences required to know the fundamentals of nanostructures and their types.
4. To get familiarize with the different thin film deposition techniques and transport phenomena.

Course Outcomes

1. This course will provide an insight into the fundamentals of Nanoscience and Nanotechnology.
2. The course provides basics of nanostructures and different types of nanostructures.
3. It also provides information about different thin film deposition techniques and transport phenomena.

INTRODUCTION

Importance of Nano-technology, Emergence of Nano-Technlogy, Bottom-up and Top-down approaches, challenges in Nano Technology.

PROPERTIES OF LOW DIMENSIONAL SYSTEM

Transport properties: quantization of conductance, density of states, Coulomb blockade, Kondo effect. Hall, quantum Hall, fractional quantum hall effects Vibrational and thermal properties: phonons, quantization of phonon modes, heat capacity and thermal transport, Optical properties: Collective oscillation (Gustav-Mie explanation), surface plasmon resonance, interactions between Nanoparticles, coupled-dipole approximation, Linear and Nonlinear optical properties.

ZERO DIMENSIONAL NANO-STRUCTURES

Nano particles through homogenous nucleation; Growth of nuclei, synthesis of metallic nano particles, Nano particles through heterogeneous nucleation; Fundamentals of heterogeneous nucleation and synthesis of nano particles using micro emulsions and Aerosol.

ONE DIMENSIONAL NANO-STRUCTURE, NANO WIRES AND NANO RODS

Spontaneous growth: Evaporation and condensation growth, vapor-liquid-solid growth, stress induced recrystallization. Template based synthesis: Electrochemical deposition, Electrophoretic deposition. Electro spinning and Lithography.

TWO DIMENSIONAL NANO-STRUCTURES:

Fundamentals of film growth. Physical vapour Depostion (PVD): Evaporation molecular beam epitaxy (MBE), Sputtering, Comparison of Evaporation and sputtering. Chemical Vapour Depostion (CVD) : Typical chemical reactions, Reaction kinetics, transport phenomena, CVD methods, diamond films by CVD.

THIN FILMS

Atomic layer deposition (ALD), Electrochemical deposition (ECD), Sol-Gel films, Advantages, Disadvantages and Applications of Thin Fils

TRANSPORT PHENOMENA

Confinement and Transport in nanostructure, Current, Reservoirs and Electron channels, Conductance formula for nanostructures, Quantized conductance. Local density of states. Ballistic transport, Coulomb blockade, Diffusive transport, Fock space.

References

1. Nano structures and Nano materials: Synthesis, properties and applications by Guozhong Cao, Imperial College press.
2. Quantum wells, Wires & Dots,: Theoretical & Computational Physics of Semiconductors Nanostuructures, Paul Harrison
3. Handbook of nanotechnology : Bhushan.
4. Nano optoelectronics : M.Grundman.
5. Nanophotonics : Paras N.Prasad.
6. Brian J. Kirby, Micro- and Nanoscale Fluid Mechanics, Cambridge University Press.

Web Links

1. https://www.bitmesra.ac.in/UploadedDocuments/Menu_634725833515825000_NSNT%20Syllabus%20for%202011%20Batch.pdf
2. http://www.manit.ac.in/manitbpl/Year2014/ordinance/PG&Ph.D%20%20new%20(2).pdf
3. https://targetstudy.com/university/108/kurukshetra-university/course/mtech-nano-science-and-technology.html
4. https://www.rgpv.ac.in/departments/nanotechdept.aspx

CORE SYLLABUS
FIRST SEMESTER

NT 103 ELECTRONIC DEVICES AND CIRCUITS

(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To study the principles of electronics Engineering
2. To understand analysis and design of simple diode circuit
3. To learn to analyze the biasing and stability of transistor at the circuit level and its role in the operation of BJT and active device
4. To study the basic design concepts of low frequency amplifiers & oscillators circuits using various transmissions for different applications

Course Outcomes

1. Able to state the operating principles of major electronic devices, circuit models and connection to the physical operation of device.
2. Ability to design and analyze simple rectifiers and voltage regulators using diodes.
3. Able to design and analyze simple BJT, MOSFET, amplifiers & oscillator circuits and also able to apply this knowledge to the analysis and design of basic circuits

DIODE CHARACTERISTICS AND APPLICATIONS

Diode working, Basic applications of PN diode, Diode specifications, Diode equivalent circuits, Characteristics of a PN diode, Volt-ampere characteristics of PN diode, Diode resistances, Diode testing, Varactor diode, Zener diode, Tunnel diode Light Emitting Diode, Photo diode, Solar cells. Rectifier Circuits: Half-wave rectifier, Full-wave rectifier, Bridge rectifier, Comparative characteristics of rectifier circuits, Filter circuits

TRANSISTOR CHARACTERISTICS AND APPLICATIONS

Operation of the transistor, Transistor configurations, Current amplification factor, β, Differences among the parameters of CE, CB and CC transistor configurations, The transistor equivalent circuits, The specification parameters correspondent to maximum ratings of BJT, Applications of transistors, Testing of transistors.

BIASING AND STABILITY OF TRANSISTORS

Biasing of amplifiers, Definition of operating point, Stability factors, Self-bias or emitter bias, Diode compensation, Thermister compensation, Sensistor compensation, Thermal runway, Thermal resistance, Thermal stability.

FIELD EFFECT TRANSISTORS

Classification of field effect transistors, Junction field effect transistors (JFET), The salient features of JFET, Comparative characteristics of JFET and BJT, Merits of JFET. Demerits of JFET, Construction of JFET, JFET characteristics, JFET parameters, Transfer characteristics, Drain characteristics, Applications of JFETs, Metal oxide semiconductor field effect transistor (MOSFET), Enhancement type MOSFET, Depletion type MOSFET, Salient features of enhancement and depletion type of MOSFET

FEEDBACK AMPLIFIERS

Expression gain with feedback, First classification of feedback amplifiers, Negative feedback amplifier, Positive feedback, Second classification of feedback amplifiers, Characteristics of negative feedback amplifier, Characteristics of positive feedback, Effect of negative feedback on gain stability, Effect of negative feedback on bandwidth, Effect of negative feedback on distortion, Effect of negative feedback on non-linear distortion, Effect of negative feedback on noise, Voltage-series feedback, Voltage-shunt feedback, Current-series feedback, Current-shunt feedback amplifier, The net effects of feedback circuits, Applications of negative feedback.

OSCILLATORS

Definition of oscillator, Definition of generator, Conditions for oscillators, Bharkhausen criteria, The characteristics of oscillators, Classification of oscillators, Sinusoidal oscillators, Relaxation oscillators, RC phase shift oscillator, Salient features of RC phase oscillator, Wein bridge oscillator, Colpitts oscillator, Hartley oscillator, The crystal oscillator

OPERATIONAL AMPLIFIERS AND APPLICATIONS

Introduction to integrated circuits, Salient features of op-amps, Symbol of op-amp, Classification of integrated circuits, Differences between linear and digital ICs, Characteristics of an ideal op-amp, Applications of operational amplifiers, The equivalent circuit of op-amp, The circuits inside an op-amp, Definitions of op-amp parameters, Frequency sensitive parameters of op-amp, Temperature sensitive parameters, Applications of linear ICs, Typical op-amps, Salient features of op-amp 741 series, Specifications of μA 741, Virtual ground concept, Applications of op-amp, Typical pin designations of op-amp

ELECTRICAL & ELECTRONIC PROPERTIES OF MATERIALS

Dielectric Materials: Polarization, Dielectric constant, refractive index, Polar and Non polar materials, Debye equation, Dielectric break down, Piezoelectricity, Pyroelectricity, Ferroelectricity; Magnetic Materials: Hysteresis curve, Soft and Hard magnetic materials, Spintronics; Optoelectronics: LEDs, Integrated Optics, Nonlinear Fabry – Perot cavities; Superconductivity: Thermodynamical treatment, Surface Energy, The Landau – Ginzburg theory, energy gap, High T_c Superconductors, New superconductors; Artificial materials or metamaterials.

References

1. G.S.N. Raju, "Electronic Devices and Circuits," IK International Publishing House Pvt. Ltd., 2006.
2. Boylestad, "Electronic Devices and Circuit Theory", Pearson Education Pvt. Ltd., 2006.
3. L. Solymar, D. Walsh " Electrical Properties of Materials". Ninth edition.
4. Electronic Devices and Circuits 2014 by A.P. Godse, U.A. Bakshi.
5. Millman's Electronic Devices and Circuits (English) 2nd Edition.
6. Dr K. Lal Kishore, B.S. Publications, 2 nd Edition 2005.
7. Electronic Devices and Circuits: second edition, S.Srinivasan, N.Suresh Kumar, Tata McGraw-Hill education, 2011.
8. Electronic Devices and Circuits: second edition, Salivahanan, N Suresh Kumar, Tata McGraw-Hill education.

Web Links

1. Electronic Devices & Circuits (English) (Paperback) by Gupta, Sanjeev|Author; Gupta, Santosh/Author
2. http://www.freebookcentre.net/electronics-ebooks-download/Electronic-Devices-and-Circuits-(PDF-313p).html
3. http://www.virginia.edu/bohr/mse209/chapter19.htm
4. http://web.utk.edu/~prack/mse201/Chapter%2019%20Electrical%20Properties.pdf
5. https://www.ucl.ac.uk/qsd/people/teaching/EOPM-Part1.pdf

CORE SYLLABUS
FIRST SEMESTER
NT 104 CARBON NANOTUBE SCIENCE AND TECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To investigate the use of carbon nanotubes as active components in organic electronic devices
2. To explore the method of synthesis and its role in obtaining CNTs with desired characteristics
3. To introduce carbon nanotube composites and its applications in different engineering fields.
4. To study the basic design concepts of MEMS and NEMS circuits for different applications

Course Outcomes

1. Able to explore the structural of carbon nanotubes, as well as the synthesis and characterization methodologies.
2. Able to estimate the behavior of carbon nano tubes in electric, magnetic, mechanical and electromagnetic field
3. Can incorporate functionalized carbon nanotubes in field MEMS and NEMS, carbon nanotube device modeling and circuit simulation

INTRODUCTION TO CARBON MATERIALS
Relationship of Carbon Nanotubes with other Carbon Materials, Structure of Bucky Balls Fullerenes and Carbon Nanotubes 4*2 =08

SYNTHESIS OF CARBON NANOTUBES
Various Techniques of Synthesis, Growth Mechanism of Bucky Balls, Fullerenes, SWCNT & MWCNT, Purification and Separation of carbon Nanotubes 4*2 =08

CHARACTERIZATION OF CARBON NANOTUBES
Physical, Mechanical & Thermal Properties of CNT, Electronic & Optical Properties, Raman & Other Spectroscopic Techniques 4*2 =08

CHEMICALLY MODIFIED NANOTUBES
Doping of CNT, Intercalation of CNT, Reactivity and Functionalisation, Opening and Filling CNT 4*2 =08

INTRODUCTION TO CARBON NANOTUBE COMPOSITES
Polymer & Metal Matrix Nanotubes Composites, Potential Application of Carbon Nanotubes, Electronics and Field Emission Applications , Supercapacitors and Actuators, Sensors and Probes, Batteries and Fuel Cell Applications, Gas Adsorption and Storage Applications, Nanotubes from Inoganic Materials, Properties of Inorganic nanotubes, Applications of Inorganic Nanotubes, Modelling of Carbon nanotubes, 6*2 = 12

MEMS AND NEMS DEVICES AND APPLICATIONS
Carbon Nanotube sensor concepts-design considerations, fabrication of the CNT sensors and state of art applications. Biosensors: Clinical Diagnostics, Classification of biosensors, immobilization characteristics applications, conducting Polymer based sensor, DNA Biosensors, optical sensors, Biochips.- 6*2 = 12

References

1. Introduction To Nanotechnology by Caharles P. Poole Jr and Frak J. Owens Wiley Indiavt. Ltd.
2. Nano Technology .and Nano Electronics – Materials, Device Measurement Technology by W.R. Fahner – Springer
3. Nanotubes and Nanowires by CNR Rao and Govind Raj

4. Carbon Nanotubes – Synthesis, Structure, Properties and Applications by Jorio A., Dressulhaus M.S (Eds), - Springer Verlaag, New York 2007-8
5. Carbon Nanotubes aand Related Structures by Peter J.F. Haris, Cambridge University Press 1st Edition 2002
6. Robert A. Freitas Jr., ―Nanomedicine Volume IIA: Biocompatibility‖, Landes Bioscience Publishers, (2003).
7. Ali Javey and Jing Kong, ―Carbon Nanotube Electronics‖ Springer Science media, (2009).
8. Michael J. O'Connell, ―Carbon nanotubes: Properties and Applications‖, CRC/Taylor & Francis, (2006).
9. Francois Leonard, ―The Physics of Carbon Nanotube Devices‖, William Andrew Inc., (2009).

Web Links

1. http://nitc.ac.in/app/webroot/img/upload/MNT_Curriculum_Syllabus_08_1.pdf
2. https://targetstudy.com/university/108/kurukshetra-university/course/mtech-nano-science-and-technology.html
3. http://www.cense.iisc.ernet.in/academics/courses.htm
4. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html
5. http://www1.iitb.ac.in/~crnts/
6. http://nanotechcell.smvdu.net.in/
7. http://files.sathyabamauniversity.ac.in/syllabus/2010%20PG%20SYLLABUS%20PDF%20COPY/Nano.pdf
8. http://www.presiuniv.ac.in/web/syllabus/syllabus_DBS.pdf
9. http://www.rtu.ac.in/RTU/wpcontent/uploads/2015/06/MTech_Nanotechnology_12_13.pdf
10. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

FIRST SEMISTER
ELECTIVE - I
NT 105: 1 CHEMISTRY OF NANOMATERIALS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To provide knowledge about chemistry-based nanoprocess
2. To design and conduct experiments relevant to nanochemistry, as well as to analyze the results.
3. To enhance the various nano-synthesis techniques and to identify and solve problems.
4. To improve usage of chemistry for modern technology.

Course Outcomes

1. Able to gain the adequate knowledge on various nanochemistry aspects.

SIZE EFFECTS ON STRUCTURE AND MORPHOLOGY OF NANOPARTICLES

Fundamental Properties - Size Effects on Structure and Morphology of Free or Supported Nanoparticles - Size and Confinement Effects - Fraction of Surface Atoms - Specific Surface Energy and Surface Stress - Effect on the Lattice Parameter - Nanoparticle Morphology - Equilibrium Shape of a Macroscopic Crystal - Equilibrium Shape of Nanometric Crystals - Morphology of Supported Particles.

SUPERPLASITICITY AND REACTIVITY OF METAL NANOPARTICLE

Superplasticity – Introduction – Mechanism - Superplastic Nanostructured Materials - Industrial Applications .Reactivity of Metal Nanoparticles - Size Effects-Structural Properties - Electronic Properties - Reactivity in Chemisorption and Catalysis of Monometallic Nanoparticles - Support Effects - Alloying Effects - Effect of Surface Segregation - Geometric Effects -Electronic Effects- Preparation and Implementation in the Laboratory and in Industry.

SUPRAMOLECULAR CHEMISTRY

Supramolecular Chemistry: Applications and Prospects - From Molecular to Supramolecular Chemistry - Molecular Recognition - Anionic Coordination Chemistry and Recognition of Anionic Substrates - Multiple Recognition Applications and Prospects.

SUPERCRITICAL FLUIDS

Supercritical Fluids –Introduction – Physicochemical Properties – Solubility-Viscosity Diffusion -Thermal Conductivity - Applications – Purification and Extraction - Synthesis.

FEATURES OF NANOSCALE GROWTH

Specific Features of Nanoscale Growth – Introduction - Thermodynamics of Phase Transitions- Dynamics of Phase Transitions - Thermodynamics of Spinodal Decomposition Thermodynamics of Nucleation – Growth - Size Control - Triggering the Phase Transition- Application to Solid Nanoparticles - Controlling Nucleation - Controlling Growth - Controlling Aggregation. Stability of Colloidal Dispersions - Breaking Matter into Pieces.

CHEMISTRY ASPECTS

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

References

1. C. Brechignac, P. Houdy, M. Lahmani, “Nanomaterials and Nanochemistry”, Springer publication 2007.
2. Kenneth J. Klabunde, “Nanscale materials in chemistry”, Wiley Interscience Publications 2001.
3. C. N. Rao, A. Muller, A. K. Cheetham, “Nanomaterials chemistry”, Wiley-VCH 2007.

Web Links

1. https://targetstudy.com/university/108/kurukshetra-university/course/mtech-nano-science-and-technology.html
2. https://www.annauniv.edu/academic_courses/00.%20WS%20-%2025.03.14%20-%20final%20(2.1.15)/05.%20Tech/Nanoscience%20and%20Tech.pdf
3. http://jsnn.ncat.uncg.edu/

FIRST SEMESTER
ELECTIVE - I
NT 105: 2 GREEN NANOTECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To make the students familiar with the field of traditional manufacturing to green manufacturing.
2. To familiarize with various processing of sustainable green manufacturing.
3. To familiarize with different types of waste management.
4. To develop the knowledge about the basic concepts of Industrial ecology.

Course Outcomes

1. Can able to implicit the importance of green manufacturing technology.
2. Able to identify suitable structures for green nanotechnology.

GREENER NANOSYNTHESIS

Greener Nanosynthesis: Greener Synthetic Methods for Functionalized Metal Nanoparticles, Greener Preparations of Semiconductor and Inorganic Oxide Nanoparticles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods.

NANOMATERIALS FOR "GREEN" SYSTEMS

Green materials, including biomaterials, biopolymers, bioplastics, and composites Nanotech Materials for Truly Sustainable Construction: Windows, Skylights, and Lighting. Paints, Roofs, Walls, and Cooling. Multifunctional Gas Sensors, Biomimetic Sensors, Optical Interference Sensors Thermo-, light-, and stimulus-responsive smart materials Nanomaterials

NANOMATERIALS FOR ALTERNATIVE ENERGY

Nanomaterials for Fuel Cells and Hydrogen Generation and storage, Nanostructures for efficient solar hydrogen production, Nanomaterials for Solar Thermal Energy and Photovoltaic. Semiconductor Nanocrystals and Quantum Dots for Solar Energy Applications Nanoparticles for Conducting Heat Transfer

NANOTECHNOLOGY IN REMEDIATION

Nanoremediation: Identification and characterization of Hazardous waste, Nano Pollution, Air-Water - Soil Contaminants, Identification and Characterization of Organic and inorganics, Environmental cleanup technologies. Nanomaterials-Remediation: Nano Membranes, Nano Meshes, Nano Fibres, Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Nano-sensors.

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 hydroxyalkanoates)- Plastics from vegetable oils - Cellulose and starch based materials -Natural fillers, fibers, reinforcements and clay nanocomposites -Biodegradability, life cycle assessment and economics of using natural materials. Micro and nanofibrillar cellulose- Cellulose is a biodegradable material that has been extensively used in paper production. Production of nanofibrils by wood pulp may lead to a great innovation for paper and packaging industry

References

1. T. David Allen and David R. Shonnard, “Green engineering” Prentice Hall NJ, 2002.
2. David Dornfeld, “ Green manufacturing fundamental and application” Prentice hall, 2002,
3. G.Sammy Shinga, “Green electronics design and manufacturing “Prince Publications, 2008
4. James clark, “Green chemistry” Blackwell publishing, 2008.

5. Paulo Davim, “Sustainable Manufacturing” Wiley publications, 2010.
6. Frank Kreith, George Tchobanoglous, “Solid waste management” McGraw Hill, 2002.
7. E. S. Stevens “Green plastics” Princeton university press, 2002.
8. U. Robert Ayres “ A Handbook of Industrial Ecology” Edward Elgar publishing, 2002

Web Links

1. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf
2. http://cdn.intechopen.com/pdfs-wm/33321.pdf
3. http://www.isca.in/rjrs/archive/special_issue2013/3.ISCA-ISC-2013-11MatS-07.pdf

FIRST SEMESTER
ELECTIVE - I
NT 105: 3 NANOSCALE MAGNETIC MATERIALS AND DEVICES
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

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

Course Outcomes

1. Can able to explore the relationship between the performance of magnetic devices and the microstructural characteristics of the materials from which they are constructed.

INTRODUCTION
Magnetic fundamentals –Antiferromagnetic materials – Domains and the magnetization process– Coercivity of fine particles –Magnetic anisotropy at nanoscale; Magnetostriction and the effect of stress; Domains and magnetization process. Electron transport in magnetic multi-layers – Spin polarized electron tunneling – Interlayer exchange coupling – Spin relaxation in magnetic metallic layers and multi-layers - Non-equilibrium spin dynamics in laterally defined magnetic structures.

NANOMAGNETISM
Two-spin channel model - Two terminal spin electronics – Three terminal spin electronics - Spin tunneling - Study of ferromagnetic and antiferromagnet interfaces – Photoemission Electron Microscopy - X-ray Absorption Spectroscopy - X-ray Magnetic Linear Dichroism (XMLD) - X-ray Magnetic Circular Dichroism (XMCD) - Temperature dependence of X-ray Magnetic Dichroism. Field models of magnetization; Exchange model in two dimensions; Magnetic domains and domain walls; Random anisotropy model of amorphous magnet; Landau-Lifshitz equation; Spin waves; Magnetic resonance; Angular momentum and spin; Magnetism of atoms

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

MAGNETIC DATA STORAGE AND RECORDING
Magnetic data storage – Disk formatting – Partitioning – Hard disk features – Hard disk data transfer modes – Programmed I/O – Direct memory access – Ultra DMA – Data addressing – Standard CHS addressing – Extended CHS addressing – Logical Block Addressing – Magnetic re cording- Principles of magnetic recording - Magnetic digital recording - Perpendicular recording - Magneto-Optic recording - Magnetic media – Kerreffect – Faraday Effect

MAGNETIC MATERIALS IN APPLICATIONS
Magnetic sensors and Giant Magnetoresistance - Optically transparent materials - Soft ferrites- Nanocomposite magnets - Magnetic refrigerant – High T_C superconductor – Ferro/biofluids– Biomedical applications of magnetic nanoparticles. Magnetic materials in applications; Magnetoresistive Sensors Based on Magnetic Tunneling Junctions; Magnetoresistive Random Access Memory (MRAM); Emerging Spintronic Memories; Giant Magnetoresistive (GMR) Spin-Valve Biosensors; Semiconductor Spin-Lasers; Spin Logic Devices and magnetic drug delivery; Magnetic materials in memory device.

References

1. HANS P.O AND HOPSTER H., ‘’Magnetic microscopy of Nanostructures” , Springer , 2004.

2. Bland J.A.C., and B. Heinrich.B “ Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism ”, Springer ,2004.
3. Nicola A.S., “ Magnetic Materials: Fundamentals and Device Applications”, Cambridge University Press ,2003
4. Handbook of Spin Transport and Magnetism, Edited by Evgeny Y. Tsymbal, Igor Zutic, Tailor and Francis, 1st edition.
5. Advances in Nanoscale Magnetism, Proceedings of the International Conference on Nanoscale Magnetism ICNM-2007, June 25 -29, Istanbul, Turkey, Series: Springer Proceedings in Physics, Vol. 122.

Web Links

1. http://jmi.ac.in/upload/programme/information_bulletin_mtech_nanotechnology.pdf
2. http://onlinelibrary.wiley.com/doi/10.1002/adma.201002180/pdf
3. http://www.engineering.leeds.ac.uk/teaching/faculty/module?navtop=&cmd=moduledetail&level=pg&progcode=MSC-SOMS/NE&module=JUSHPY003

FIRST SEMESTER
ELECTIVE - I
NT 105: 4 MICRO AND NANO MECHANICS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To study about quantum crystals and its structure in different dimensions.
2. To understand the stress, strain and elastic relation in between different crystalline and non-crystalline
3. To provide a knowledge of basic concept of strength of materials for designing a mechanical component.

Course Outcomes

1. Gain adequate knowledge on crystalline behavior of solids.
2. Apply the concepts of advanced strength of materials for designing the mechanical components

INTRODUCTION: LINEAR ATOMIC CHAINS:
A model binary molecule (Two, three and N atoms Linear chain), Linear chain with optical modes, Quantum Mechanics and Thermodynamics of the linear chain, Effect of temperature on the Linear chain, Quantum Operators for normal modes.

TWO AND THREE-DIMENSIONAL LATTICES
Crystals, Two – Dimensional Crystals, Three – Dimensional Crystals, Periodic Functions, Bloch's Theorem, Classical Theory of the Lattice, Normal Mode Hamiltonian, Connection to the Classical Continuum Theory of Solids.

STRESS, STRAIN AND ELASTICITY RELATIONS
Relative displacement and Strain, Principal Axes of Strain, Superposition, The Stress Tensor and their properties, Inhomogeneous Stresses and Arbitrary Shapes, Body forces, Classes of Linear Elastic response, Isotropic, Orthotropic, Crystalline and Polycrystalline Materials, Stress – strain relations.

STATIC DEFORMATIONS OF SOLIDS
System of Equations for a static deformable solids, Extensional forces, Flexure of Beams, Euler – Bernoulli Theory of Beams, Torsional Beam, Two and Three Dimensional Problems.

DYNAMIC BEHAVIOR OF SOLIDS & DISSIPATION AND NOISE IN MECHANICAL SYSTEMS
Simple vibrational methods, Dynamical Equations of motion in an isotropic solid, Waves in infinite isotropic solids, Waves in infinite crystalline solids, Waves in semi - infinite isotropic solids, Waves in plates and Waves in rods, Langevin equation, Zener's model of an Anelastic solid, Thermoelastic relaxation, Phonon – phonan Interactions, Dissipation in Nanoscale Mechanical Resonators.

NON-LINEAR EQUATION
Introduction, roots of a non-linear equation and roots of a polynomial of n^{th} degree [incremental search method, method of successive approximations, Newton's method, bisection method, secant method] and convergence study

LINEAR ALGEBRAIC EQUATIONS
Solution of (non-homogeneous) linear algebraic equations, review of matrix algebra, Gauss elimination method, Cholesky's decomposition method, householder method, Gauss-Siedal iterative method; Solution of non-linear algebraic equations, method of successive approximation, Newton's method, modified Newton – Raphson method, secant method

EIGEN VALUES AND EIGEN VECTORS
Eigen values and Eigen vectors, reduction of generalized Eigen value problem to the standard Eigen value problem, methods for obtaining Eigen values and Eigen vectors

References

1. Andrew. N. Cleland "Foundations of Nanomechanics: From Solid – State Theory to Device Applications", Springer International Edition, 2005.
2. Chapra, S. C. and Canale, R. P., "Numerical Methods for Engineers", Tata McGraw hill
3. Robert Kelsall, Ian W. Hamley, Mark Geoghegan "Nanoscale Science and Technology" John Wiley & Sons, 2006.
4. Wing Kam Liu, Eduard G. Karpov, Harold S. Park "Nano Mechanics and Materials: Theory, Multiscale Methods and Applications", John Wiley & Sons, 2006.

Web Links

1. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

FIRST SEMESTER
ELECTIVE - I
NT 105: 5 NANOIONICS: CONCEPTS AND TECHNOLOGICAL APPLICATIONS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To provide knowledge on phenomena, properties, effects, methods and mechanisms of processes connected with fast ion transport (FIT) in all-solid-state nanoscale systems.

Course Outcomes

1. Able to explore fast ion transport in nanoscale devices.

INTODUCTION

Solid state ionics vis-à-vis solid state electronics, Principles of ionic conduction in ordered and disordered nanostructures.

SUPER IONIC MATERIALS

Superionic materials classification – Crystalline anionic and cationic conductors, mixed ionic and electronic conductors, structural factors responsible for high ionic conductivity; Brief review on physical techniques for analysis of ion conducting solids

ION TRANSPORT

Transport properties and Ion dynamics; Ion transport in homogeneous and heterogeneous medium – Ion conducting glasses, ceramics, polymers and composites; Ion Transport Models - Phenomenological models, Free volume theory, Configurational entropy model, Jump relaxation and Ion hopping model, Bond percolation model and Effective medium theory. Concepts and feasibility of ion conducting polymer nanocomposites and nanocrystalline ceramics.

MATERIAL PROBLEMSAND PROCESSING TECHNIQUES

Technological applications of ion conducting solids; Design, Fabrication and Evaluation of Solid State Lithium Batteries, Supercapacitors (EDLC and Redox), Fuel Cells (PEM Fuel cell, SOFC), Gas sensors and display devices. Thermodynamics and mass transport in solid sate batteries. Battery performance and electrode kinetics. Double layer and other polarization effects at solid /solid interface; Fuel Cells as micro-power houses, Power conditioning and control of fuel cell systems.

References

1. Superionic Solids : Principles and Applications, S. Chandra, North Holland, 1981
2. Solid State Ionics, T. Kudu and K. Fueki, Kodanasha-VCH, 1990
3. Lithium Batteries : Research, Technology & Applications, Greger R. Dahlin, Kalle E. Strøm, Nova Science Pub Inc, 2010.
4. Energy Storage, R. A. Huggins, Springer, 2010.
5. Electrochemical Supercapacitors: Scientific Fundamentals & Technological Applications, B. E. Conway, Kluwer Academic, 1999
6. Fuel Cell Technology, Nigel Sammes (ed.), 1st edition, Springer, 2006
7. Clean Energy, R. M. Dell & D. A. J. Rand, Royal Society Publications, 2004
8. Fuel Cell Engines, Matthew M. Mench, John Wiley & Sons, 2008.
9. Solid State Electrochemistry, P. G. Bruce (ed.), Cambridge University Press, 1995.
10. The CRC Handbook of Solid State Electrochemistry, P. J. Gellings & H. J. M. Bauwmeester, CRC Press, 1997.
11. Solid State Electrochemistry II : Electrodes, Interfaces and Ceramic Membranes, V. V. Kharton (ed.), Wiley-VCH, 2009 .
12. Fuel Cell Technology Handbook, G. Hoogers (ed.), CRC Press, 2003 (ISBN: 0-8493-0877-1).

13. Fuel Cell Technologies: State & perspectives; N. Sammes, A. Smirnova and O. Vasylyev (eds.), Springer, 2004.

Web Links

1. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html

FIRST SEMESTER
ELECTIVE - I
NT 105: 6 NANO-CMOS CIRCUIT AND PHYSICAL DESIGN
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To make the students acquainted with the concepts of CMOS scaling.
2. To describe the practicalities of sub wavelength lithography.
3. To focus on signal integrity problems.

Course Outcomes

1. Able to implicate the basic knowledge of Nano-CMOS to design the Circuit and Physical Design.

NANO-CMOS SCALING PROBLEMS AND IMPLICATIONS

Design Methodology in the Nano-CMOS Era – Scaling – Overview of Sub-100-nm Scaling Challenges and Subwavelength Optical Lithography – Back-End-of-Line Challenges (Metallization) – Front-End- of-Line Challenges (Transistors) – Process Control and Reliability Lithographic Issues and Mask Data Explosion – New Breed of Circuit and Physical Design – Modeling Challenges– Need for Design Methodology Changes

PRACTICALITIES OF SUBWAVELENGTH OPTICAL LITHOGRAPHY

Simple Imaging Theory – Challenges for the 100-nm N ode – e-Factor for the 100-nm Node – Corner Rounding Radius – Resolution Enhancement Techniques: Specialized Illumination Patterns – Optical Proximity Corrections – Sub resolution Assist Features – Alternating Phase-Shift Masks– Physical Design Style Impact on RET and OPC Complexity – Specialized Illumination Conditions – Two-Dimensional Layouts – Alternating Phase-Shift Masks – Mask Costs

PROCESS SCALING IMPACT ON DESIGN MIXED-SIGNAL CIRCUIT DESIGN

Design Considerations – Device Modeling – Passive Components – Design Methodology– Benchmark Circuits – Design Using Thin Oxide Devices – Design Using Thick Oxide Devices– Low-Voltage Techniques – Current Mirrors – Input Stages – Output Stages – Bandgap. References– Design Procedures – Electrostatic Discharge Protection – Multiple-Supply concerns –Noise Isolation–Guard Ring Structures – Isolated NMOS Devices–Epitaxial Material versus Bulk Silicon–Decoupling–Power Busing–Integration Problems – Corner Regions – Neighboring Circuitry

ELECTROSTATIC DISCHARGE PROTECTION DESIGN

ESD Standards and Models – ESD Protection Design – ESD Protection Scheme – Turn-on Uniformity of ESD Protection Devices – ESD Implantation and Silicide Blocking – ESD Protection Guidelines – Low-C ESD Protection Design for High-Speed I/O – ESD Protection for High-Speed I/O or Analog Pins – Low-C ESD Protection Design – Input Capacitance Calculations – ESD Robustness – Turn-on Verification – ESD Protection Design for Mixed-Voltage I/O – Mixed-Voltage I/O Interfaces – ESD Concerns for Mixed-Voltage I/O Interfaces – ESD Protection Device for a Mixed-Voltage I/O Interface – ESD Protection Circuit Design for a Mixed-Voltage I/O Interface – ESD Robustness – Turn-on Verification – SCR Devices for ESD Protection – Turn-on Mechanism of S CR Devices – SCR-Based Devices for CMOS On-Chip ESD Protection

SIGNAL INTEGRITY PROBLEMS IN ON-CHIP INTERCONNECTS

Interconnect Figures of Merit – Interconnect Parasitics Extraction – Circuit Representation of Interconnects – RC Extraction –Inductance Extraction – Signal Integrity Analysis – Interconnect Driver Models – RC Interconnect Analysis – RLC Interconnect Analysis – Noise-Aware Timing Analysis – Design Solutions for Signal Integrity – Physical De sign Techniques – Circuit Techniques

References

1. Ban P. Wong, Anurag Mittal, Yu CaoGreg Starr, "Nano-CMOS Circuit and physical design", John Wiley & Sons, Inc.Hoboken, New Jersey,2000.
2. Charles chiang, Jamil Kawa, "Design for manufacturability and yield for Nano - Scale CMOS", Springer, 2007.

Web Links:

1. http://www.cense.iisc.ernet.in/academics/courses.htm
2. http://jmi.ac.in/upload/programme/information_bulletin_mtech_nanotechnology.pdf
3. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf.
4. http://jntua.ac.in/syllabus/ECE/M.Tech.%20%20Micro%20and%20NanoElectronics.pdf
5. http://www.iitr.ac.in/academics/uploads/File/2015/syllabi/syllabinano.pdf

FIRST SEMESTER
ELECTIVE - I
NT 105: 7 QUANTUMN MECHANICS FOR NANOTECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To achieve an understanding of the theory of quantum mechanics, and an ability to apply the quantum theory to important physical systems.
2. To appreciate the applications of quantum mechanics in physics, engineering, and related fields.
3. To become aware of the necessity for quantum methods in the analysis of physical systems of atomic and solid-state physics.
4. Explain scientifically the new applications of quantum physics in computation.

Course Outcomes

1. Gain adequate working knowledge of the foundations, techniques, and key results of quantum mechanics.
2. Can able to apply quantum mechanics for solving problems in physics and nanotechnology.

THE SCHRODINGER'S EQUATION AND ITS MATHEMATICAL IMPLICATION

Development of Time Dependent Schrodinger's equation - Statistical interpretation of wave function - Normalization of wave function – Conservation of total probability, Dynamical variables and Hermitian operators - position, and linear and angular momentum operators – Commutation relations- Ehrenfest theorem - Heisenberg uncertainty principle, Time Independent Schrodinger equation– Properties of energy Eigen functions, Expansion postulate.

BOUND STATES & QUANTUM TUNNELING

Free particle - Momentum Eigen functions, Energy levels of a particle – Infinite square well in one, two, and three dimensions - Density of states – Confined carriers - Electron wave propagation in devices - Quantum confinement - Penetration of a barrier – Tunnel effect - Basic principles of a few effective devices – Resonant tunnel diode, Superlattice , Quantum wire and Dot.

QUANTUM DYNAMICS

Time development of the wave function - Time evolution operator - Schrodinger, Heisenberg, and Interaction pictures of quantum dynamics - Time evolution - Free particle wave packet, One-dimensional harmonic oscillator , Two-state quantum systems.

ANGULAR MOMENTUM

Rotation operators, Angular momentum operators, Commutation rules, Eigenvalues of angular momentum operator, Matrix representations, Addition of two angular momenta, Clebsch-Gordon coefficients.

IDENTICAL PARTICLES AND SCATTERING THEORY

System of Identical particles – Symmetrization of wave functions - Exchange interactions - Free electrons in a metal – Fermi gas - Mutual scattering of two particles – Separation of Schrodinger equation in laboratory and center of mass frames - Scattering of a wave packet, Born approximation, Validity, Partial wave analysis, Phase shift. Quantum theory of Scattering – Differential and total cross sections, Scattering amplitude – Derivation using Green's functions - Born approximation -Scattering by spherically symmetric potentials.

QUANTUM COMPUTATION

Quantum Bits - Single qubit gates - Multiple qubits – Controlled Not gate, Swap gate, Toffoli gate, Bell states - no-cloning theorem - Quantum Teleportation - Deutsch's Algorithm - Deutsch-Jozsa Algorithm - Quantum Fourier transform.

References

1. B.H. Bransden and C.J. Joachain, “Quantum Mechanics”, Pearson, 2007.
2. David J. Griffiths, “Introduction to Quantum Mechanics”, Pearson, 2009.
3. Richard L. Liboff, “Introductory Quantum Mechanics”, Pearson, 2003.
4. Mark Lundstrom, “Fundamentals of Carrier Transport”, Cambridge University Press, 2000.
5. Yoav Peleg, Reuven Pnini, Elyahu Zaarur, and Eugene Hecht, “Schaum’s Outline of Quantum Mechanics” , Tata McGraw Hill, 2010.
6. Eugen Merzbacher, “Quantum Mechanics”, John Wiley & Sons, 1999.
7. P.M. Mathews and K. Venkatesan, “Quantum Mechanics”, Tata McGraw Hill, 2010.
8. Ajoy Ghatak and S. Lokanathan, “Quantum Mechanics”, Macmillan, 2009.
9. Michael A. Nielsen & Isaac L. Chuang, “Quantum Computation and Quantum Information”, Cambridge University Press, 2002.
10. L. Schiff, Quantum Mechanics, Mc Graw-Hill Book Co., New York, 1996.
11. E.Merzbacher, Quantum Mechanics, Wiley International, New York, 1970.

Web Links

1. http://jmi.ac.in/upload/programme/information_bulletin_mtech_nanotechnology.pdf
2. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf.
3. http://jntua.ac.in/syllabus/ECE/M.Tech.%20%20Micro%20and%20NanoElectronics.pdf
4. http://www.iitr.ac.in/academics/uploads/File/2015/syllabi/syllabinano.pdf

FIRST SEMESTER
ELECTIVE – I
NT 105: 8 ADVANCED FINITE ELEMENT ANALYSIS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To introduce the concepts of Mathematical Modeling of Engineering Problems.
2. To appreciate the use of FEM to a range of 1D, 2D and 3D Engineering Problems.

Course Outcomes

1. Can able to understand different mathematical techniques used in fem analysis.
2. Ability to use fem analysis in structural and thermal problem.
3. Ability to introduce the concepts of mathematical modeling of engineering problems.
4. Ability to use fem to a range of 1D, 2D and 3D engineering problems

INTRODUCTION

Introduction to FEM, basic concepts, historical back ground, applications of FEM, general description, comparison of FEM with other methods**,** Finite elements of an elastic continuum - displacement approach, basic element shapes, interpolation function, generalization of the finite element concept - weighted residuals and variational approaches, Virtual energy principle, Rayleigh – Ritz method, properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics, Basic equations of elasticity, strain- displacement relations. Plane stress and plane strain, Requirements of Convergence, h – refinement and p - refinement

1-D STRUCTURAL PROBLEMS

Axial bar element – stiffness matrix, load vector, temperature effects, Quadratic shape functions and problems, Plane Trusses and Space Truss elements and problems

2-D PROBLEMS

CST, LST, force terms, Stiffness matrix and load vectors, boundary conditions, Isoparametric elements – quadrilateral element, shape functions – Numerical Integration.

Finite element modelling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements.

ANALYSIS OF BEAMS AND FRAMES

Hermite shape functions – stiffness matrix – Load vector – Problems related to Beams and Frames

3-D PROBLEMS

Tetrahedran element – Jacobian matrix – Stiffness matrix.

STEADY-STATE SCALAR FIELD PROBLEMS

1D. 2 D Heat conduction, electric and magnetic potentials, field flow. The time domain, semi-descritization of field and dynamic problems and analytical solution procedures.

DYNAMIC CONSIDERATIONS

Dynamic equations – consistent mass matrix – Eigen Values, Eigen vector, natural frequencies – mode shapes – modal analysis.

ANALYSIS OF PLATES

Introduction, Triangular Membrane element, Quadratic Triangle element, Rectangular plate element (in-plane forces), Bending behavior of plates, finite element analysis of plates in bending, triangular plate bending element.

References

1. Concepts and Applications of Finite Element Analysis by Cook, R.D.
2. Applied Finite Element Analysis by Segerland, L.J.

3. The Finite Element Methods in Engineering / SS Rao / Pergamon.
4. Finite Element Methods: Basic Concepts and applications, Alavala, PHI
5. Introduction to Finite Elements in Engineering, Chandrupatla, Ashok and Belegundu, Prentice – Hall
6. Finite Element Method – Zienkiewicz / Mc Graw Hill
7. Introduction to Fininte element analysis- S.Md.Jalaludeen, Publications, print-2012
8. A First Course in the Finite Element Method/Daryl L Logan/Cengage Learning/5th Edition
9. Finite Element Method – Krishna Murthy / TMH
10. Finite Element Analysis – Bathe / PHI

Web Links

1. http://www.iitg.ernet.in/engfac/rtiwari/resume/usdixit.pdf
2. https://en.wikipedia.org/wiki/Finite_element_method
3. http://www.sv.vt.edu/classes/MSE2094_NoteBook/97ClassProj/num/midkiff/theory.html
4. http://www.iue.tuwien.ac.at/phd/radi/node29.html
5. https://en.wikiversity.org/wiki/Introduction_to_finite_elements/Axial_bar_finite_element_solution#Shape_functions
6. http://civil.colorado.edu/~saouma/3525/MathCad-Examples.pdf
7. http://webserver.dmt.upm.es/~isidoro/ot1/Thermal%20effects%20on%20materials.pdf

FIRST SEMESTER
ELECTIVE – II
NT 106: 1 THIN FILM TECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To teach scientific principles behind thin film technology.
2. To familiarize them with the principles, equipment, use, and limitations of different deposition techniques.
3. To give students an overview of the phenomena and concepts involved in thin film.

Course Outcomes

1. One can able to segregate the deposition technique based on the application.
2. Can aware of specific characterization techniques for evaluation of effective formation of thin film.

INTRODUCTION TO THIN FILMS

Technology as a drive and vice versa; Structure, defects, thermodynamics of materials, mechanical kinetics and nucleation; grain growth and thin film morphology; Basics of Vacuum Science and Technology,

THIN FILM GROWTH TECHNIQUES

Introduction – Kinetic theory of gases - gas transport and pumping; vacuum pumps and systems - vacuum gauges - oil free pumping - aspects of chamber design from thin film growth perspectives Physical vapour deposition techniques – Physics and Chemistry of Evaporation - Thermal evaporation – Pulsed laser deposition – Molecular beam epitaxy – Sputtering deposition – DC, RF, Magnetron, Ion beam and reactive sputtering - Chemical methods - Thermal CVD – Plasma enhanced CVD – Spray Pyrolysis–Sol-Gel method– Spin and Dip coating –Electro plating and Electroless plating–Deposition mechanisms - Langmuir Blodgett technique.

CHARACTERIZATION TECHNIQUES

Surface analysis techniques – Auger Electron spectroscopy – Photoelectron Spectroscopy– Secondary Ion Mass Spectroscopy – X-ray Energy Dispersive

Analysis – Rutherford Backscattering spectroscopy - Imaging Analysis Techniques – Scanning Electron Microscopy – Transmission Electron Microscopy – Optical analysis Techniques – Ellipsometry – Fourier Transform Infrared Spectroscopy – Photoluminescence Spectroscopy

ADSORPTION AND DIFFUSION IN THIN FILMS

Physisorption – Chemisorption – Work function changes induced by adsorbates–Two dimensional phase transititions in adsorbate layers – Adsorption kinetics – Desorption techniques. Fundamentals of diffusion – Grain Boundary Diffusion – Thin Film Diffusion Couples - Inter Diffusion-Electro migration in thin films – Diffusion during f ilm growth

STRESS IN THIN FILM

Origin of Thin film stress - Classifications of stress – Stress in epitaxial films– Growth Stress in polycrystalline films – Correlation between film stress and grain structure – Mechanisms of stress evolution – film stress and substrate curvature – Stoney formula – Methods of curvature measurement –Scanning laser method.

MODIFICATION OF SURFACES AND FILMS

Introduction – Laser and their Interactions with Surfaces – Laser modification effects and applications – Laser sources and Laser scanning methods - Thermal analysis of Laser annealing-Laser surface alloying - Ion implantation effects in solids – Energy loss and structural modification– compositional modification - Ion beam modification phenomena and applications

References

1. Amy E. Wendt, “Thin Films - High density Plasmas”, Volume 27, Springer Publishers. 2006.
2. Rointan F. Bunshah,” Hand Book of Deposition technologies for Thin Films and coatings by Science, Technology and Applications”,Second Edition , Noyes Publications, 1993.
3. Milton Ohring, “Materials Science of Thin films” Published by Academic Press Limited 1991.
4. L.B. Freund and S.Suresh, “Thin Film Materias”, 2003.
5. Hans Luth, “Solid surfaces, Interfaces and Thin Films”’ 4th edition, Springer Publishers 2010.
6. Thin Film Solar Cells, Chopra and Das.
7. Thin Film Deposition: Principles and Practice, Donald Smith.
8. Handbook of Thin Film Deposition (Materials and Processing Technology), Krishna Seshan.
9. Handbook of Physical Vapor Deposition, D. M. Mattox.

Web Links:

1. http://www.unom.ac.in/index.php?route=department/department/syllabus&deptid=18
2. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf.
3. http://jmi.ac.in/upload/programme/information_bulletin_mtech_nanotechnology.pdf
4. http://jntuh.ac.in/new/academic/nano-science.html
5. http://jntuk.edu.in/directorates/evaluation/news/news-editor/article-1361884380

FIRST SEMESTER
ELECTIVE – II
NT 106: 2 STATISTICAL THERMODYNAMICS FOR NANOSYSTEMS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. The objective of this course is to make the students acquire depth of knowledge in the concepts of statistical mechanics and thermodynamics and to apply it to different nanoscale systems.
2. The objective of this course is to make the students understand the thermodynamics of small systems and non-equilibrium thermodynamics
3. The objective of this course is to make the students apply the principles of thermodynamics and statistical mechanics in new formulations.

Course Outcomes

1. At the end of the course one can able to understand and explore the reason behind heat released during working of a nono-systems.

THERMODYNAMICS OF SMALL SYSTEMS

Non-intensivity and Nonextensivity of Nanosystems -The Gibbs Equation for Nanosystems-Statistical Mechanics and Thermodynamic Property Predictions – Standard polymorphs-formalisms of controlled nucleation and growth of nanocystallites from a vitreous state-thermodynamics of polymorphic transformations in non-porous and nanoporous solids.

NANOTHERMODYNAMICS

Different Approaches to Nanothermodynamics-surface thermodynamics-Phase transitions in nanoparticles-quasi chemical description of solid nanoparticles- size dependent interface energy-thermodynamics of confined fluids in nanopores-structural properties of nanoclusters-Hill's approach to Nanothermodynamics-Phase transition in nanosystems-symmetry of fullerenes-PI index of some carbon nanotubes.

NON-EQUILIBRIUM THERMODYNAMICS

Thermostated Dynamical Systems - The Transient Fluctuation Theorem Thermodynamic Interpretation of the Dissipation Function - The Dissipation Theorem- Nonequilibrium Work Relations- Nonequilibrium Work Relations for Thermal Processes - Corollaries of the Fluctuation Theorem and Nonequilibrium Work Relations -Generalized Fluctuation Theorem - Integrated Fluctuation Theorem -Second Law Inequality - Nonequilibrium Partition Identity - The Steady State Fluctuation Theorem- Minimum Average Work Principle .

NONEQUILIBRIUM NANOSYSTEMS

Basics-Nanosystems Driven by Time-Dependent Forces-Jarzynski's Nonequilibrium Work Theorem- Mechanical Nanosystems- Friction in Double-Walled Carbon Nanotubes-Electromagnetic Heating of Microplasmas-Mechanochemical Nanosystems-F1-ATPase Motor-Continuous state description-Discrete state description- Chemical Nanosystems- Chemical Transistor- Chemical Clocks in Field Emission Microscopy-DNA replication.

THERMODYNAMICS OF BIOLOGICAL SYSTEMS

Crystal-melt interfacial energies and solubilites for nanosized systems- Via the Ostwald-Freundlich equation, the size-selective growth process of nanoparticles-Bulk memberane partition- Nanothermodynamics of a Single Molecule- The Concept of Pseudo equilibrium-Cellular and Sub-cellular Systems.

References

1. D. V. Ragone, "Thermodynamics of Materials", John Wiley & Sons, 1994.
2. David R. Gaskell, "Introduction to the Thermodynamics of Materials", Taylor & Francis, 2002.
3. Michael Rieth and Wolfram Schommers, "Handbook of Theoretical and Computational

Nanotechnology”, American Scientific Publishers, 2005.
4. C. H. P. Lupis, “Chemical Thermodynamics of Materials”, Prantice Hall, 2000.
5. J. W. Christian, “Theory of Phase Transformations in Metals and Alloys”, Pergamon Press, 2001.
6. Günter Radons, Benno Rumpf and Heinz Georg Schu ster, “Nonlinear Dynamics of Nanosystems”, Wiley publishers, 2010.

Weblinks:

1. http://jntuk.edu.in/directorates/evaluation/news/news-editor/article-1361884380
2. http://nitc.ac.in/app/webroot/img/upload/MNT_Curriculum_Syllabus_08_1.pdf
3. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf.

FIRST SEMESTER
ELECTIVE – II
NT 106: 3 SPECTROSCOPIC TECHNOQUES FOR NANOMATERIALS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To make the students acquire knowledge with the concepts of atomic and molecular spectra
2. To make the students understand the principles underlying various spectroscopies and instrumentations specific to nanomaterials.
3. To make the students apply the laws, concepts and principles in problem solving and new formulations.

Course Outcomes

1. Can explore basic principles of spectroscopy and to lay emphasis on advanced Spectroscopic techniques for nanomaterials and the fundamentals

NANO OPTICS

Basic Concepts-Spontaneous Emission- Classical Bound- Radiating Electron-Quantum Mechanical Radiative Decay-Absorption and Emission -Nano-optics and local spectroscopy-. Electromagnetic radiation and its interaction with matter, natural line width and broadening, electronic structures of free atoms and ions, splitting of levels and terms in chemical environment, construction of energy level diagram, relation of energy level diagrams to spectral properties, selection rules and polarization in electronic transitions, vibronic transitions, Franck-Condon principle, electronic spectra of polyatomic molecules, emission spectra, radiative and non-radiative decay.

MOLECULAR SPECTROSCOPIES OF NANOASSEMBLIES

Simplified model for vibrational interactions-Characteristic bands for organic compounds -Attenuated-total reflection (ATR) and grazing incidence angle techniques-Reflection-absorption IR spectroscopy (RAIRS)-The Raman Effect- Lateral and in-depth Resolution of Conventional μRS- Resonant Raman Spectroscopy (RRS) - Nano-specific Modes- Surface-Enhanced Raman Spectroscopy (SERS)- Nano-Raman- Phase Identification and Phase Transitions in Nanoparticles- Characterizing Carbon Materials with Raman Spectroscopy.

NONLINEAR SPECTROSCOPIES

Absorption saturation and harmonic generation, Second-harmonic generation (SHG) and sum frequency spectroscopy (SFG) - Luminescence up conversion-The use of nonlinear optical methods to obtain infrared spectra of ultra-thin assemblies confined to surfaces.

LUMINESCENCE SPECTROSCOPY

Optical properties of assembled nanostructures-interaction between nanoparticles-Direct and indirect gap transitions-, -Single molecule and single nanoparticles spectroscopy-Dynamic light scattering spectroscopy Fluorimetry and Chemiluminescence - X-ray fluorescence spectrometry-Atomic emission spectroscopy.

ELECTRON SPECTROSCOPIES FOR NANOMATERIALS

X-Ray Beam Effects, Spectral Analysis -Core Level Splitting Linewidths - Elemental Analysis: Qualitative and Quantitative -Secondary Structure ,XPS Imaging -Angle-Resolved - Basic Principles of AES-Instrumentation-Experimental Procedures Including Sample Preparation - AES Modifications and Combinations with other Techniques -Auger Spectra: Direct and Derivative Forms and Applications-Electron energy loss spectroscopy of Nanomaterials.

References

1. Vladimir G. Bordo and Horst-Günter Rubahn; "Optics and Spectroscopy at Surfaces and Interfaces" John-Wiley and Sons, Inc., 2005.
2. William W. Parson, "Modern Optical Spectroscopy", Springer, 2007.
3. Harvey Elliot White, "Introduction to Atomic Spectra", McGraw Hill, 1934.

4. Francis Rouessac and Annick Rouessac, “Chemical Analysis-Modern Instrumentation Methods and Techniques”, 2000.
5. Joseph. R. Lakowicz “Principles of fluorescence spectroscopy”, Springer, 2010.
6. Pavia, Lampman, Kriz, Vyvyan, “Introduction to spectroscopy”, Cengage learning, 2009.
7. Jin Jhong Jhang, “Optical properties and spectroscopies of Nanomaterials”, World Scientific Publishing 2009.
8. Banwell, Fundamentals Of Molecular Spectroscopy, Tata Magraw Hill, 2008

Web Links:

1. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

FIRST SEMESTER
ELECTIVE – II
NT 106: 4 BIONANOTECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To understand the basic knowledge of Nanobiotechnology and DNA structures.
2. To gain the basic knowledge on the application of Nanomaterials in biotechnology and acquire the knowledge about the DNA, proteins, amino acids, drug delivery, biomedicine etc.,
3. To provide the knowledge in basics of nanotechnology in biotechnology.
4. To make the students understand about the functional principles of bio-nanotechnology

Course Outcomes

1. Can gain the introductory knowledge on the theory and practice of bio-nanotechnology

OVERVIEW OF NANOBIONANOTECHNOLOGY
Historical perspective of integration of biology, chemistry and material science opportunities and promises of nanobiotechnology.

BIOLOGICAL MOLECULES AND THEIR ANALYSIS
Complexity and size of biological molecules – DNA, RNA proteins and carbohydrates; Techniques: Biological analysis electrophoretic and chromatographic analysis – basic principles and applications.

SINGLE MOLECLE APPROACHES IN BIOTECHNOLOGY
Fluorescence – spectroscopy-Fluorescent probes for analysis of proteins and nucleic acids. Labeling of proteins and nucleic acids by acids by various fluorescent dyes. Molecular beacons and applications.

MODERN BIOMATERIALS
Proteins, Nucleic acids, Lipids, Polysaccharides.

MICROBIOLOGY AND NANOTECHNOLOGY
Bacteria viruses: Prokaryotic complexity and size distribution; Bacterial cell-to –cell communication, quorum sensing, chemotaxis; Microbial production of inorganic nanoparticles; Gold nanoparticles for imaging and therapy.

MINIATURIZED DEVICES-NANOTECHNOLOGY AND MEDICAL DEVICES
Overview of smart devices for medical field; miniaturized devices for drug delivery; advantages of miniaturized devices; lab on chip concept; epipen; intelligent pill; wobbling gels.

NANOMATERIALS USED IN BIOTECHNOLOGY
Nanoparticles; carbon nanotubes; fullerenes; nanofibres; quantum dots and buckyballs interface with biological macromolecules; Biological perspectives of Nanomaterials: Impact of Nanomaterials in biological process; tolerance by immune systems and toxicity; Nucleic acid Engineering: Modifications of DNA for nanotechnological applications; Nanostructure assembly using DNA.

STRUCTURAL PRINCIPLES OF BIONANOTECHNOLOGY
Natural Bionano-machinery, Hierarchical strategy, raw materials, Protein folding, self-assembly and self- organization, molecular recognition and flexibility.

BIONANOTECHNOLOGY TODAY AND FUTURE
Bionanotechnology Today and Future: Basic capabilities, Nanomedicine today, DNA computers, hybrid materials, artificial life and biosensors.

References

1. Berg, J.M., Tymoczko, J.L., and Stryer, L., “Biochemistry”, 6thEd. - W. H. Freeman and Company, NewYork.

2. Goodsell, D.S., “Bionanotechnology: Lessons from Nature”, Wiley Press.
3. Niemeyer, C.M. and Mirkin, C.A., (Editor). “Nanotechnology: Concepts, Applications and perspectives” , Wiley Press.
4. Weish, C., “Antibiotics: Action, Origins, and resistance” , ASM Press
5. Arya, D.P., “Aminoglycoside Antibiotics: From Chemical biology to Drug Discovery” Wiley Press.
6. Labhasehwar, V., and Leslie-Pelecky, D.L., (editor), “Biomedical Applications of Nanotechnology” , Wiley Press.
7. Klussman, S., “The Aptamer Handbook : Functional Oligonucleotides and their Applications” , Wiley VCH Press.
8. Paulter Adans, R.L., Knwler, L., and Leader, D.P., “The Biochemistry of the Nucleic Acids” Springer verlag GmbH.
9. Nanobiotechnology- Concepts, Applications and Perspectives Niemeyer C.M. & Mirkin, C.A. 2004,Wiley-VCH Verlag.
10. Bionanotechnology- Lessons from Nature ,Goodsell, David S. 2004, John Wiley & Sons INC., Publication.

Web Links

1. https://www.bitmesra.ac.in/UploadedDocuments/Menu_634725833515825000_NSNT%20Syllabus%20for%202011%20Batch.pdf.
2. hindustanuniv.ac.in/nano_tech.php
3. http://www.iitr.ac.in/academics/uploads/File/2015/syllabi/syllabinano.pdf
4. http://jntuh.ac.in/new/academic/nano-science.html
5. http://jntuk.edu.in/directorates/evaluation/news/news-editor/article-1361884380
6. http://vtu.ac.in/nano-technology/
7. http://jntua.ac.in/syllabus/ECE/M.Tech.%20%20Micro%20and%20NanoElectronics.pdf

FIRST SEMESTER
ELECTIVE – II
NT 106: 5 NANO MATERIALS FOR ENERGY AND ENVIRONMENT
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To demonstrate knowledge of the sources of energy and the methods of energy Conversion in Nanotechnology.
2. To appreciate the role of Nano technology in energy and its efforts to improve lifestyle.
3. Understand the basic principles of Renewable Energy technology, Micro Fuel Cell Technology and Micro Fluid System.
4. To conduct experiments to verify basic principles of energy conversion.

Course Outcomes

1. Can able to explore various forms of energy used in industries and methods of converting from one form to another by using Nanotechnology.
2. One can familiar with how the energy converted and how their use impact on the environment particularly in terms of nanotechnology.

ENERGY OVERVIEW

Types of Energy and its utilization- Energy Characteristics, Energy Measures, Fundamentals of environment, Environmental aspects of energy utilization, Public health issues related to environmental pollution, Pollution Standards, environmental impact assessment

NANOMATERIALS USED IN ENERGY AND ENVIRONMENTAL APPLICATIONS AND THEIR PROPERTIES

Evaluation of properties and performance of practical power systems that benefit from optimization of materials processing approaches.

DEVICE APPLICATIONS

Sensors, power semiconductor chips, fuel cells, superconductors, solar cells, energy storage and other alternative power sources. Solar cells, Thin film Si solar cells, Chemical semiconductor solar cells, Dye sensitized solar cells, Polymer solar cells, Nano quantum dot solar cells, Hybrid nano-polymer solar Cells

INTRODUCTION TO FUE CELLS

Fuel Cells, principle of working, basic thermodynamics and electrochemical principle, Fuel cell classification, Fuel cell Electrodes and Carbon nano tubes, application of power and transportation.

ENERGY, HYDROGEN STORAGE AND PRODUCTION

Fuel Cells, Battery, Solar energy Conversion, Nanomaterials in Automobiles.

References

1. W.F.Kenney, Energy conservation in the process industries, Academic Press, 1984
2. Tetsuo Soga, Nanostructured Materials for Solar energy conversion, Elsevier
3. Robert k, Ian H, Mark G, Nanoscale science and Technology, John Wiley & sons ltd, 2005.

Web Links

1. http://amity.edu/aint/A12028.asp
2. https://www.annauniv.edu/academic_courses/00.%20WS%20-%2025.03.14%20-%20final%20(2.1.15)/05.%20Tech/Nanoscience%20and%20Tech.pdf
3. http://jntuh.ac.in/new/academic/nano-science.html
4. http://jntuk.edu.in/directorates/evaluation/news/news-editor/article-1361884380
5. http://vtu.ac.in/nano-technology/
6. https://www.bitmesra.ac.in/UploadedDocuments/Menu_634725833515825000_NSNT%20Syllabus%20for%202011%20Batch.pdf.
7. hindustanuniv.ac.in/nano_tech.php

FIRST SEMESTER
ELECTIVE – II
NT 106: 6 MICRO/NANO COLLIDALS AND EMULSIONS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To define and identify emulsions and emulsifying agents.
2. To understand the mechanism of emulsions and the process of stabilization.
3. To provide basic knowledge on formulation and characterization of emulsions.

Course Outcomes

1. Can explore micro/nano emulsions used in industry as components in a huge range of formulated products or as effect chemicals in the production or processing of other materials.

INTRODUCTION

Definition of nano- and micro- emulsions – Reason f or their long term kinetic stability – Practical application in personal care products and cosmetics, healthcare products, pharmaceuticals and agrochemicals – Schematic representation of oil/water and water/oil emulsions – Comparison with micelles and macroemulsions – Methods of emulsification: Pipe flow, static mixers and general stirrers, high-speed mixers, colloid mills and high pressure homogenizers – continuous and batch-wise p reparations – turbulent flow.

MECHANISM OF EMULSIFICATION

Role of interfacial energy – Explanation of the high energy required for formation of nanoemulsions –The Laplace pressure concept – Role of surfactants: Reduction in interfacial tension and the effect on droplet size – Gibbs adsorption equation – Interfacial dilational modulus and droplet deformation –Interfacial tension gradients and the Marangoni effect - Solubilization theories: Concept of a duplex film and bending of the interface to form o/w or w/o emulsions – Phase diagrams of ternary systems of water, surfactant and cosurfactant – Concept of normal and inverse micelles – Quarternary phase diagrams of oil/water surfactant and cosurfactant – Solubilization of oil by nonionic surfactants

FORMULATION OF EMULSION

High pressure homogenization and efficiency of preparation – The Phase Inversion Temperature (PIT) principle – Variation o f interfacial tension with temperature – Phase diagrams as a function of temperature – Formulation of microemulsions– Selection of microemulsions: Hydro philicLipophilic Balance (HLB) concept – Phase Inversion Temperature (PIT) concept – Cohesive Energy Ratio (CER) concept.

CHARACTERIZATION OF EMULSIONS

Scattering techniques: Time average light scattering – Neutron scattering – Quasi-elastic light scattering (Photon Correlation Spectroscopy(PCS)) – Conductivity and NMR techniques: Conductivity of water/oil microemulsions, percolating and non-percolating emulsions, discontinuous emulsions – Viscosity of emulsions – NMR technique for measurement of self diffusion of all components in emulsions and explanation of the various structures.

STABILITY OF EMULSION

Steric stabilization: Unfavorable mixing of the stabilizing chains – Entropic repulsion – Total energy – Distance curves for sterically stabilized emulsions– Variation of the energy curve with the ratio of adsorbed layer thickness to droplet radius – Thermodynamic stabilization: Reason for combining surfactant and cosurfactant to produce an ultra low interfacial tension – Formation of a model w/o emulsion using 4 steps – Relationship of droplet size to interfacial tension.

References

1. Seid Mahdi Jafari, “Encapsulation of nano-emulsions by spray drying”, Lambert

Academic Publishing, 2009.
2. Hans Lautenshlager “Emulsions”, Kosmetik International, 2002.
3. Roque Hidalgo-Alvarez, “Structure and Functional properties of Colloids”, CRC Press, 2009.
4. Richard J. Fann, “Chemistry and Technology of Surfactants”, Wiley-Blackwell, 2006.

Web Links

1. http://web.stevens.edu/nano/courses.php
2. hindustanuniv.ac.in/nano_tech.php
3. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

FIRST SEMESTER
ELECTIVE – II
NT 106: 7 NANOSCALE INTEGRATED COMPUTING

Theory: 4 periods/week | **Internal : 30**
Credits: 4 | **External: 70**

Course Objectives

1. To understand the evolution of computing technology and its significance.
2. To understand the major advance in computing architectures involving "spin-wave Buses".
3. To appreciate the computing architectures and algorithms in medical nanorobotics.

Course Outcomes

1. Can gain the adequate knowledge on Nanoscale integrated computing for emerging technology with potential applications.
2. Able to explore the importance of nanoscale architecture which provides an increased computational speed, power-efficient, reduces the space requirements for interconnects and allows for fundamentally new computing paradigms.

AN INTRODUCTION TO NANOCOMPUTING

Micro computing era – Transistor as a switch, difficulties with transistors at the nanometer scale– Nanoscale devices – Molecular devices – Nanotubes – Quantum dots – Wave computing – Quantum computing.

QUANTUM COMPUTING

Reversible computations – Quantum computing models – Complexity bounds for quantum computing – Quantum compression – Quant um error correcting codes – Quantum cryptography– Computing with quantum dot cellular automata – Quantum dot cellular automata cell – Ground state computing –Clocking – QCA addition – QCA multiplication – QCA memory – 4-bitprocessor

SPIN-WAVE ARCHITECTURES

Spin wave crossbar – Spin wave reconfigurable mesh – Spin wave fully interconnected cluster– Multi-scale Hierarchical architecture – Spin wave based logic devices – Logic functionality– Parallel computing with spin waves – Parallel algorithm design techniques – Parallel routing and broadcasting – On-Spin wave crossbar – On-Spin wave reconfigurable mesh–On-Spin wave fully interconnected cluster.

MOLECULAR COMPUTING

Switching and memory in molecular bundles – molecular bundle switches – Circuit and architectures in molecular computing – Molecular grafting for silicon computing – Molecular grafting on intrinsic silicon nanowires – Self assembly of CNTs

COMPUTATIONAL TASKS IN MEDICAL NANOROBOTICS

Medical Nanorobot designs – Microbivores – Clottocytes – Chromallocytes – Common functions requiring onboard computation – Nanorobot control protocols: Operation protocols– Biocompatibility protocols – Theater protocols – Nanoscale image processing: Labeling problem– Convex Hull problem – Nearest neighbor problem.

References

1. Nielsen M. A. and Isaac L. Chuang, "Quantum computation and quantum information", Cambridge University Press, 2000.
2. Jain A. K., "Fundamentals of Digital Image Processing", Prentice-Hall, 1988.
3. Schroder D. K., "Semiconductor Material and Device Characterization", New York, 2006.
4. Zhou C. and New Haven, "Atomic and Molecular wires", Yale University Press, 1999.

Web Links:

1. http://jntua.ac.in/syllabus/ECE/M.Tech.%20%20Micro%20and%20NanoElectronics.pdf
2. http://jntuh.ac.in/new/academic/nano-science.html

3. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

FIRST SEMESTER
ELECTIVE - II
NT 106: 8 COMPUTATIONAL FLUID DYNAMICS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To impart knowledge about various computational methods of fluid flow and solve Simple fluid flow problems.
2. To recognize the nature of the fluid problem and apply boundary conditions.
3. To design a system or process and simulate to meet desired needs and solves engineering applications.

Course Outcomes

1. Able to understand the compressible and incompressible flow fluids.
2. Ability to select the governing equations for conduction and convection fluid flow applications.
3. Able to apply different boundary conditions according to the fluid problem.
4. Acquires knowledge about grid generation processing and applications of CFD.
5. Ability to solve real world problems.

INTRODUCTION
Finite difference method, finite volume method, finite element method, governing equations and boundary conditions. Derivation of finite difference equations.

SOLUTION METHODS
Solution methods of elliptical equations - finite difference formulations, interactive solution methods, direct method with Gaussian elimination.
Parabolic equations-explicit schemes and Von Neumann stability analysis, implicit schemes, alternating direction implicit schemes, approximate factorization, fractional step methods, direct method with tridiagonal matrix algorithm.

HYPERBOLIC EQUATIONS
Explicit schemes and Von Neumann stability analysis, implicit schemes, multi step methods, nonlinear problems, second order one-dimensional wave equations.
Burgers equations: Explicit and implicit schemes, Runge-Kutta method.

FORMULATIONS OF INCOMPRESSIBLE VISCOUS FLOWS
Formulations of incompressible viscous flows by finite difference methods, pressure correction methods, vortex methods.

TREATMENT OF COMPRESSIBLE FLOWS
Potential equation, Eluer equations, Navier-stokes system of equations, flowfield-dependent variation methods, boundary conditions, example problems.

FINITE VOLUME METHOD
Finite volume method via finite difference method, formulations for two and three-dimensional problems.

STANDARD VARIATIONAL METHODS – 1
Linear fluid flow problems, steady state problems,

STANDARD VARIATIONAL METHODS – 2
Transient problems.

References

1. Computational fluid dynamics, T. J.Chung, Cambridge University press,2002.
2. Text book of fluid dynamics, Frank Chorlton, CBS Publishers & distributors, 1985.
3. Numerical heat transfer and fluid flow / Suhas V. Patankar/ Hema shava Publishers corporation & Mc Graw Hill.

4. Computational Fluid Flow and Heat Transfer/ Muralidaran/ Narosa Publications
5. Computational Fluid Dynamics: Basics with applications/John D. Anderson/ Mc Graw Hill.
6. Fundamentals of Computational Fluid Dynamics/Tapan K. Sengupta / Universities Press.
7. Introduction to Theoretical and Computational Fluid Dynamics/C. Pozrikidis /Oxford University Press/2nd Edition

Web Links

1. https://en.wikipedia.org/wiki/Computational_fluid_dynamics
2. http://www.bakker.org/dartmouth06/engs150/05-solv.pdf
3. https://en.wikipedia.org/wiki/Numerical_methods_in_fluid_mechanics
4. https://en.wikipedia.org/wiki/Navier%E2%80%93Stokes_equations
5. http://www.cscamm.umd.edu/publications/hangzhou_CS-05-04.pdf

FIRST SEMESTER
NT 107 SYNTHESIS OF NANOMATERIALS LAB
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 3 **Internal:100**
Credits: 3

Course Objectives

1. To know the importance of the synthesis method addressed in the material properties and give practical experience of nanomaterials synthesis/properties and characterization; investigations into the various factors influence the properties of nanomaterials, optimizing the procedures, and implementations to the new designs

Course Outcomes

1. Able to synthesize nanoparticle using chemical method, physical method and also mechanical method.

1. Synthesis of Nanostructures / Nano composites by Sol-gel Process
2. Nano – material Preparation by Chemical methods
3. Methods for the synthesis of nanomaterials and thin film technology (CVD method, Spin Coating, Spray Pyrolysis and Sputtering)
4. Composite preparation by using Ball Milling.

References

1. Advanced catalysis and Nano structured material by WR Moser.
2. Introduction to Nano Technology by Charles. P.Poole Jr and Frank J. Owens Wiley India Pvt Ltd.
3. Encyclopedia of Nanotechnology by H.S. Nalwa

Web Links

1. http://www.uio.no/studier/emner/matnat/kjemi/KJM5100/h06/undervisningsmateriale/10KJM5100_2006_sol_gel_d.pdf
2. http://www.ewp.rpi.edu/hartford/users/papers/engr/ernesto/morens/EP/References/Chemical%20Vapor%20Deposition.pdf

FIRST SEMESTER

NT 108 COMPUTER AIDED MODELING AND SIMULATION

(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 3 **Internal: 100**

Credits: 2

Course Objectives

1. To acquire basic understanding of Modeling and Analysis software.
2. To gain the knowledge on different numerical methods to solve simple and complex problems.

Course Outcomes

1. Prepare simple (1D) and complex (3D) solids in CAD software and obtain solutions to projections and sections of solids.
2. Able to solve complex problems using numerical methods.

TOOLS

Practical approach to learning operating systems (DOS, UNIX, Windows) and Graphical packages (Origin, Gnuplot)--RAVI

PROGRAMMING

C and C++: Character set, variables, constants, Data types and their declarations, relational operators, logical operators, arithmetical operations, built in functions, input output statements, functions, subroutine, Array handling.—D A NAIDU

NUMERICAL METHODS I -- RAVI

Matrices, Solution of system of linear equations, direct methods, error analysis, curve fitting, iterative methods; Numerical differentiation and integration methods, quadrature formula and Monte-Carlo methods, Numerical methods for ordinary equations, stability and convergence.

NUMERICAL METHODS II --- D A NAIDU

Interpolation, extrapolation, Numerical solution of partial differential equation, Initial value problems.

RANDOM NUMBERS -- RAVI

Monte carlo integral methods, importance sampling, fast fourier transform. Physical simulations: N body methods and particle simulations, Verlet algorithm, molecular dynamics and monte carlo methods. Simulation of small system and Ab initio methods.

ARGUS LAB SOFTWARE PRACTICE -- D A NAIDU

Nanotechnology related work practice exercises of Molecular modeling and mechanics *programs*

PURDUE UNIVERSITY PRISM SOFTWARE PRACTICE – RAVI & NAIDU

Nanotechnology related work practice exercises of MEMS devices *programs*

References

1. Numerical Methods for Scientific and Engineering Computation, M. K. Jain, S. R. K. Iyengar and R. K. Jain, Wiley Eastern
2. Handbook of Theoretical and Computational Nanotechnology, Eds. Michael Rieth and Wolfram Schommers, 2006
3. Introductory Computational Physics Andi Klein and Alexander Godunov (Cambridge)

Web Links

1. http://www.purdue.edu/discoverypark/prism
2. http://www.arguslab.com/arguslab.com/ArgusLab.html

CORE SYLLABUS
SECOND SEMESTER
NT 201 CHARACTERIZATION OF MATERIALS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. Beginners will be able to acquaint themselves with the excited subject though they are novice, whereas advanced learners will equip themselves to solve the complicated issues further.
2. To know the importance of the characterization; investigations into the various factors influence the properties of nanomaterials, optimizing the procedures, and implementations to the new designs

Course Outcomes

1. Able to identify the suitable technique for characterization of nano materials and devices.

INTRODUCTION AND PRELIMINARY CONCEPTS
Macro-, Meso-, Micro- and Nanostructure of Materials, Fundamentals of crystallography and Crystal structures.

X-RAY DIFFRACTION METHODS
X-ray production, Bragg's Law, Laue's Equation, Diffraction Methods, Single Phase analysis, Multi-Phase Analysis, Particle size and strain, Orientation and Texture, Residual Stress.

OPTICAL MICROSCOPY
Geometry of Optics, Resolution, Construction of a Microscope, Image Contrast, Phase Contrast.

RESONANCE METHODS
Electron Spin Resonance (ESR), Ferromagnetic Resonance (FMR), Nuclear Magnetic Resonance (NMR), Mossbauer Spectroscopy, Thermal Characterization of Materials: DTA, TGA, DSC (Principle and Applications), Determination of thermo physical parameters.

FOURIER TRANSFORMATION INFRARED SPECTROSCOPY
Michelson Interferometer, Sources and Detectors, Fourier Transformations, Moving Mirror, Signal Averaging, Advantages, Computers, Spectra.

PROBE TECHNIQUES
Deep level transient spectroscopy (DLTS), Scanning Probe Microscopy (SPM), Atomic Force Microscopy (AFM), Kelvin-probe measurements. Nanoscale current-voltage (I-V), capacitance-voltage (C-V) relationships.

SCANNING ELECTRON MICRISCOPY
Electron Optics - Cathodes, Electron Lenses, Aberrations, Resolution, Interaction of Electrons and Matter-Elastic and Inelastic Scattering, Backscattered Electrons, Secondary Electrons, Scanning Electron Microscopy - Image Formation, EPMA, Magnification, Depth of Field, Distortion, Detectors, Contrast, and Resolution.

TRANSMISSION ELECTRON MICROSCOPY
Electron diffraction, reciprocal lattice, analysis of SAD patterns; different electron diffraction techniques. Electron Microscopy, EDS: X-ray microanalysis: Energy dispersive X-ray spectroscopy (EDS) and Quantitative microanalysis using EDS.

References

1. Microstructural Characterization of Materials by **David Brandon** and **Wayne Kaplan**, John Wiley and Sons, New York, NY, 1999.
2. Elements of X-ray Diffraction by **B. D. Cullity** and **S.R. Stock**, Prentice Hall, New Jersey, 2001.
3. Thermal Analysis of Materials, **Robert F Speyer**, New York.

4. Scanning Electron Microscopy and X-Ray Microanalysis, 3rd ed. **Joseph I. Goldstein**, Dale E. Newbury Academic/Plenum Publishers, New York, 2003.
5. "Transmission Electron Microscopy" by **David B. Williams** and **Barry Carter**, Plenum Press, NY. London 1996 (or a newer edition).
6. Hand Book of Nanophase & Nanomaterials: **Zhong Lin Wang** (Springer) (Vol. I&II).
7. Thermal Analysis of Materials, Robert F speyar, New York.
8. Nanotechnology: Nanostructures and Nanomaterials, By M Balakrishna Rao and K. Krishna Reddy, Campus Books, New delhi, ed.-2007
9. Nanostructures & Nano Materials: Ghuzang Cao
10. Nanostructures: Tsakalakos, Ovidko & Vasudevan
11. Physics of Amorphous Solids: Richard Xylen
12. Nanostructured Films & Coatings: Gang Moog Chow
13. Hand Book of Nanophase :Zhong Lin Wang (Springer) & Nanomaterials (Vol. I&II)
14. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton

Web Links

1. https://www.bitmesra.ac.in/UploadedDocuments/Menu_634725833515825000_NSNT%20Syllabus%20for%202011%20Batch.pdf
2. http://jntua.ac.in/syllabus/ECE/M.Tech.%20-20Micro%20and%20NanoElectronics.pdf
3. hindustanuniv.ac.in/nano_tech.php
4. http://www.presiuniv.ac.in/web/syllabus/syllabus_DBS.pdf
5. http://www.ptu.ac.in/userfiles/file/mtech_syllab/6-7-15%20mtech%20nanotechnology%202007%20onward.pdf
6. http://www.bput.ac.in/syllabus/Final_Updated_New_Syllabus_mtech_BPUT__2009-10__polymer_nanotech.pdf
7. http://www.manit.ac.in/manitbpl/Year2014/ordinance/PG&Ph.D%20%20new%20(2).pdf
8. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html
9. https://www.iitm.ac.in/curricula/M.Tech-M-2012.pdf

CORE SYLLABUS
SECOND SEMESTER
NT 202 MICRO AND NANO FABRICATION
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. Demonstrate proficiency in the basic subfields of Engineering Physics as well as other areas of recent applications.
2. Through critical thinking, problem solving in device designs of Micro-/Nano instruments.
3. Construct and assemble experimental ideas, analyze available measurements of physical phenomena and their related things.

Course Outcomes

1. Can able to understanding in fabrication of micro/nano devices and their architectures of sensing applications.

MEMS &NEMS

Materials Aspects of Micro Electro Mechanical Systems (MEMS) and Nano Electro Mechanical Systems (NEMS) Silicon, Germanium-Based Materials, Metals, Harsh Environment Semiconductors, GaAs, InP, and Related III-V Materials, Ferroelectric Materials and Polymer Materials.

BASIC MICROFABRICATION TECHNIQUES

Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding.

SELF ASSEMBLY AND ANALYSIS

Process of self assembly, semiconductors islands, monolayers, nature of catalysis, porous materials, pillared clays, colloids, biometrics.

MEMS FABRICATION TECHNIQUES

Bulk Micromachining, Surface Micromachining, High-Aspect-Ratio Micromachining.

NANOFABRICATION TECHNIQUES

E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing.

STAMPING TECHNIQUES FOR MICRO AND NANO-FABRICATION

High Resolution Stamps, Microcontact Printing and Nanotransfer Printing, Applications of printing techniques, Unconventional Electronic Systems, Lasers and Waveguide

References

1. Micro and Nano Fabrication by Mark.J.Jackson.
2. Nanostructures : Tsakalakos, Ovidko & Vasudevan .
3. Physics of Amorphous Solids : Richard Xylen.
4. Processing & properties of structural naonmaterials - Leon L. Shaw (editor)
5. Nanochemistry: A chemical approach to nanomaterials by G. A. Ozin, A. C. Aresnault, L. Cadematriri, RSC Publishing
6. Microfabrication and Nanomanufacturing Mark James Jackson
7. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al
8. Nanoscale Characterization of surfaces and Interfaces, N.John DINardo, Wiley, September 2008
9. Tester, J. W, Drake E. M, Golay M. W, Driscoll M. J., and Peters W. A.. Sustainable Energy - Choosing Among Options. Cambridge, MA: MIT Press, 2005.
10. Scott J.F., Ferroelectric Memories. Springer. ISBN 3540663878 (2000)

Web Links

1. https://www.annauniv.edu/academic_courses/00.%20WS%20-%2025.03.14%20-%20final%20(2.1.15)/05.%20Tech/Nanoscience%20and%20Tech.pdf
2. http://www.info.vit.ac.in/cnr/Services.asp
3. http://www.presiuniv.ac.in/web/syllabus/syllabus_DBS.pdf
4. http://www.bput.ac.in/syllabus/Final_Updated_New_Syllabus_mtech_BPUT__2009-10__polymer_nanotech.pdf
5. http://www.manit.ac.in/manitbpl/Year2014/ordinance/PG&Ph.D%20%20new%20(2).pdf
6. http://www.rtu.ac.in/RTU/department-of-nano-technology
7. https://www.bitmesra.ac.in/UploadedDocuments/Menu_634725833515825000_NSNT%20Syllabus%20for%202011%20Batch.pdf
8. http://jntua.ac.in/syllabus/ECE/M.Tech.%20%20Micro%20and%20NanoElectronics.pdf
9. http://www.kampuzz.com/courses/detail/38928-mtech-in-micro-amp-nano-electronics
10. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html
11. http://www.cense.iisc.ernet.in/academics/courses.htm

CORE SYLLABUS
SECOND SEMESTER
NT 203 POLYMER NANOCOMPOSITES
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To demonstrate the nano sized materials-containing particles in a polymeric matrix.
2. To understand the methodology and specific methods of fabrication of hybrid polymer-inorganic nanocomposites.
3. To know the mechanism of particle stabilization by polymeric surfactants.

Course Outcomes

1. Can able to analyzes the essential data on nanoscale materials dispersed in, or chemically bonded with polymers.
2. One can synthesis nanocomposites, and evaluate their chemical interactions, and the size and distribution of the particles in the polymer matrix

INTRODUCTION OF NANOCOMPOSITES

Nanocomposites, Definition, Nanocomposites past and present, Nomenclature, Solids - Atomic and molecular solids, Role of statistics in materials, Primary, secondary and tertiary structure, Transitions.

PROPERTIES AND FEATURES OF NANOCOMPOSITES

Physics of modulus, Continuum measurements, Yield, Fracture, Rubbery elasticity and viscoelasticity, Composites and nanocomposites, Surface mechanical properties, Diffusion and permeability, Features of nanocomposites, basics of polymer nano composites - Nanoreinforcements, Matrix materials, Hazards of particles

NANOCOMPOSITES

Metal-Metal nanocomposites, Polymer-Metal nanocomposites, Ceramic nanocomposites: Dielectric and CMR (Collosion Magneto Resistance) based nanocomposites. (One example for each type).

FABRICATION/PROCESSING OF NANOCOMPOSITES

Viscosity, Types of flow, Viscosity- Experimental viscosity, Non-newtonian Flow, Low-viscosity processing, Solvent processing, Particle behavior, Direct Mixing, Solution Mixing, In-situ polymerization, In-Situ Particle Processing Ceramic/Polymer Composites, In-Situ Particle Processing Metal/Polymer Nanocomposites, Modification of Interfaces, Post-Forming, Hazards of solvent Processing, Melt, high -shear, and direct processing, Melting and softening, Melt processes with small shears or Low, shear rates flow, Melt processes with large deformations or high-shear rates, Thermo-kinetic processes.

CHARACTERIZATION OF NANOCOMPOSITES

Introduction to characterization, Experiment design, Sample preparation, Imaging, Structural characterization, Scales in nanocomposites, Texture, Electromagnetic energy, Visualization, Physicochemical analysis, Characterization of physical properties, Identification, Mechanical, Surface mechanical, Exposure, Barrier properties, Recipes and standards

APPLICATIONS OF NANOCOMPOSITES

Nanocomposites, Optical, structural applications, Nanoparticulate systems with organic matrices, Applications, Biodegradable protein nanocomposites, Applications of Polypropylene nanocomposites, Application as exterior automatic components, Hybrid nanocomposite materials, Application for corrosion protection, Applications of Nanopolymers in Catalysis.

References

1. Thomas E. Twardowski, Introduction to Nanocomposite Materials, Properties, Processing, Characterization, DesTech Publications, April 2007

2. Nanocomposite Science and Technology Pulickel M. Ajayan , Linda S. Schadler , Paul V. Braun, 2006, Wiley-VCH.
3. Polymer nanocomposites: Edited by Yiu-Wing Mai and Zhong-Zhen Yu, First published 2006, Woodhead Publishing Limited and CRC Press LLC, USA.

Web Links:

1. https://www.bitmesra.ac.in/UploadedDocuments/Menu_634725833515825000_NSNT%20Syllabus%20for%202011%20Batch.pdf
2. hindustanuniv.ac.in/nano_tech.php
3. https://www.iitm.ac.in/curricula/M.Tech-M-2012.pdf
4. http://www.iitr.ac.in/academics/uploads/File/2015/syllabi/syllabinano.pdf
5. http://www.iitkgp.ac.in/downloads/brochure_nepa.pdf
6. https://www.amrita.edu/program/m-tech-nanotechnology-renewable-energy
7. http://www.pondiuni.edu.in/sites/default/files/downloads/mtech_nano.pdf
8. http://jntua.ac.in/syllabus/ECE/M.Tech.%20%20Micro%20and%20NanoElectronics.pdf

CORE SYLLABUS
SECOND SEMESTER
NT 204 NANOFLUIDS SCIENCE AND TECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. The general objective of this course is to introduce the students to application of nanotechnology in the area of fluids.
2. Demonstrate to the students the superior thermophysical properties of nanofluids.
3. Show through analytical and numerical analyses corroborated by experimental data that heat transfer systems will be smaller and will require less pumping power for the same amount of heat transfer using nanofluids, in comparison to conventional fluids used today.
4. Guide the students to research on this new topic to design modern mini and microchannel heat exchangers with nanofluids exhibiting much higher thermal efficiency and saving energy.

Course Outcomes

1. Apply the knowledge of nanotechnology in fluids and thermal engineering.
2. Design a system, component, or process to meet desired needs using nanofluids.
3. Identify, formulate and solve fluid dynamic and thermal engineering problems involving nanotechnology.
4. Have the capability to carry out nanofluid based research project.

INTRODUCTION

Fundamentals of kinetic theory-molecular models, micro and macroscopic properties, binary collisions, distribution functions, Boltzmann equation and Maxwellian distribution functions-Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows. Fundamentals of cooling, Fundamentals of nanofluids, Making nanofluids, Mechanisms & Models for enhanced thermal transport, Future research.

SYNTHESIS OF NANOFLUIDS

General issues of nanofluids, Synthesis methods-common issues, Study of nanoparticles, Variety in nanomaterials, Micro emulsion based methods for nanofluids, Solvo thermal synthesis, Synthesis using supports, Synthesis using biology, Magnetic nanofluids, Inert gas condensation, Anisotropic nanoparticles, Other nanofluids, summary.

CONDUCTION HEAT TRANSFER IN NANOFLUIDS

Conduction heat transfer, Measurement of thermal conductivity of liquids, Thermal conductivity of oxide nanofluids, Temperature dependence of thermal conductivity enhancement, Metallic nanofluids, nanofluids with CNTs.

THEORETICAL MODELING OF THERMAL CONDUCTIVITY OF NANOFLUIDS

Simple mixture rules, Maxwell approach, Particle distribution, Particle geometries, Symmetrical equivalent medium theory, Matrix particle interfacial effects, Dynamic models of thermal conductivity of nanofluids.

CONVECTION IN NANOFLUIDS

Fundamentals of convective heat transfer, convection in suspensions & slurries, Convection in nanofluids, Analysis of convection in nanofluids, Numerical studies of convection in nanofluids.

BOILING OF NANO-FLUIDS

Fundamentals of boiling, Pool boiling of nanofluids, Critical heat flux in pool boiling of nanofluids, other investigations related to boiling of nanofluids.

APPLICATIONS AND FUTURE DIRECTIONS

Liquid cooling, Applied research in nano cooling, Further research.

References

2. Nano Fluids Science and Technology by Sarit Kumar Das, John Wiley and sons.
3. Joshua Edel ―Nanofluidics, RCS publishing, 2009.
4. Patric Tabeling ―Introduction to Microfluids‖ Oxford U. Press, New York 2005.
5. K. Sarit ―Nano Fluids; Science and Technology‖, RCS Publishing, 2007.

Web Links

1. http://www.nie.ac.in/wp-content/uploads/2015/03/M.Tech-Nanotechnology.pdf
2. http://www.manit.ac.in/manitbpl/index.php?option=com_content&view=article&id=517:coursesphysics&catid=2:uncategorised&Itemid=136

SECOND SEMESTER
ELECTIVE – III
NT 205: 1 NANOLITHOGRAPHY AND DEVICE FABRICATION
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To understand the key concepts of lithographic and microscopic resolution and apply this knowledge to estimate the intrinsic resolution limits for manipulation and imaging/inspection tools; Redefining the concepts of contrast and a transfer function for all systems and explain their role in both microscopy and lithography.

Course Outcomes

1. Able to define the concepts involved in physics and chemistry of surfaces along with the fundamental interactions amongst them.
2. Evolve how processing tools are applied to transfer nanostructured patterns into useful materials based on device architectures; analyze and evaluate proposed approaches to material processing to device designs in advance.

THE SCIENCE OF MINIATURIZATION

Moore’s Laws (1,2,&3) and technology’ Roadmap–clean rooms Processing Methods: Cleaning – Oxidation – Lithography – Etching- – CVD – Diffusion – Ion implantation – metallization – state of the art CMOS architectures Photolithography Overview – Critical Dimension – Overall Resolution– Line-Width – Lithographic Sensitivity and Intrinsic Resist Sensitivity (Photochemical Quantum Efficiency) – Resist Profiles – Contrast and Experimental Determination of Lithographic Sensitivity – Resolution in Photolithography – Photolithography Resolution Enhancement Technology

NANOSTRUCTURING BY PHYSICAL TECHNIQUES

Next-Generation Technologies: – State-Of-The-Art (including principles, capabilities, limits, applications) EUV lithography – Phase-shifting photolithography – X-ray lithography – Electron Bea m Direct Writing System – Focused ion beam (FIB) lithography – Neutral atomic beam lithography – Plasma-Aided Nanofabrication – Soft Lithography – Nanosphere Lithography– Nanoimprint – Dip-pen nanolithography – key consequences of adopted techniques

NANOMANIPULATION AND PROCESSING

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

NANOMETER DEVICES

Material Wave Nanotechnology: Nanofabrication Using a de Broglie Wave-Electron Beam Holography – Atomic Beam Holography- Nanometer Lithography Using Organic Positive/Negative Resists – Sub-10 nm Lithography Using Inorganic Resist – 40 nm-Gate-Length Metal-Oxide-Semiconductor Field-Emitter-Transistors-14 nm Gate-Length Electrically Variable Shallow Junction MOSFETs-Operation of Aluminum-Based Single-Electron Transistors at 100 Kelvin’s- Room Temperature Operation of a Silicon Single-Electron Transistor

SUB-LITHOGRAPHIC ARCHITECTURES

Fundamental scaling limits to the transistors – Beyond CMOS: Self-Assembled structures– Gravitational field assisted assembly – Template-assisted assembly- Shear force assisted assembly- Electroforming and Molding (LIGA) – Fundamentals of Quantum Computing – Quantum Algorithms - Realizing quantum computers – Physical Implementations (Josephson junction Circuits and semiconductor quantum dots).

References

1. Guozhong Cao, “Nanostructures & Nanomaterials Synthesis, Properties G; Z: Applications”, World Scientific Publishing Private Ltd., 2004.
2. W.R.Fahrner, “Nanotechnology and Nanoelectronics – Materials, Devices, Measurement Techniques”, Springer-Verlag Berlin, 2006.
3. R. H. J. Hannink and A. J. Hill, “Nanostructure control of materials”, CRC Press, 2006.
4. Zheng Cui, “ Nanofabrication, Principles, Capabilities and Limits” , Springer Science Business media, 2008.
5. Hari Singh Nalwa, “Handbook of Nanostructured Materials and Nanotechnology -Vol. 3- Electrical Properties”, Academic Press, 2000.
6. Huff, Howard, “Into the Nano Era: Moore's Law Beyond Planar Silicon CMOS”, Springer-Verlag Berlin, 2009.
7. Marc J. Madou, “Fundamentals of Microfabrication: The Science of Miniaturization”, CRC Press, 2002.
8. Kostya (Ken) Ostrikov and Shuyan Xu, “Plasma-Aided Nanofabrication: From Plasma Sources to Nanoassembly”, WILEY-VCH, 2007.

Web Links

1. http://www.ksrct.ac.in/admin/Editor/Academic/Curriculum/MTech_NANO_R2008.pdf
2. http://www.albany.edu/undergraduate_bulletin/n_eng.html
3. https://www.annauniv.edu/academic_courses/00.%20WS%20-%2025.03.14%20-%20final%20(2.1.15)/05.%20Tech/Nanoscience%20and%20Tech.pdf
4. http://jntuk.edu.in/directorates/evaluation/news/news-editor/article-1361884380
5. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

SECOND SEMESTER
ELECTIVE – III
NT 205: 2 NANOTOXICOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To provide knowledge on social impact of nano industry.
2. To design and conduct experiments, as well as to analyze the results.
3. To enhance the various analytical techniques and to identify and solve problems.
4. To understand the socio-ethical responsibility.

Course Outcomes

1. Can able to understand and analyze social impact and health issues of environmental pollution caused due to nano-industries.

POSSIBLE HEALTH IMPACT OF NANOMATERIALS

Sources of Nanoparticles; Epidemiological Evidence; Entry Routes into the Human Body – Lung, Intestinal Tract, Skin ; Nano particle Size - Surface and Body Distribution; Effect of Size and Surface Charges; Nanoparticles, Thrombosis and Lung Inflammation ;Nanoparticles and Cellular Uptake; Nanoparticles and the Blood-Brain Barrier.

NANOMATERIALS FOR ENVIRONMENTAL REMEDIATION

Introduction- Nanoparticle-based Remediation Materials - Acid-Base Chemistry - Redox Chemistry- Field Deployments of ZVI - Absorption Chemistry - Hybrid Nanostructured Remediation Materials- Self-assembled Monolayer's on Mesoporous Supports (SAMMS) - Functional CNTs.

BIOTOXICITY OF METAL OXIDE NANOPARTICLES AND CARBON NANOTUBES

Introduction; Nanoparticles in the Environment; Nanoparticles in Mammalian Systems; Health Threats; Nanomaterials and Biotoxicity; Iron Oxide; Titanium Dioxide; Dark Studies; UV Irradiation Studies; Other Metal Oxides; Toxicological Studies and Toxicity of Manufactured CNTs- case study; Toxicity of CNTs and Occupational Exposure Risk; Toxicity of MWCNTs/SWCNTs and Impact on Environmental Health.

TOXICOLOGY OF NANOPARTILES IN ENVIRONMENTAL POLLUTION

Air Pollution; Introduction to Air Pollution Particles; Adverse Effects of PM in Epidemiological Studies; Role of Nanopartides in Mediating the Adverse Pulmonary Effects of PM; Effects of Nanopartides on the Cardiovascular System; Nanopartide Translocation and Direct Vascular Effects; Endothelial Dysfunction and Endogenous Fibrinolysis; Coagulation and Thrombosis; Cardiac Autonomie Dysfunction; Effects of Nanopartides on the Liver and Gastrointestinal Tract; Effects of NP on the Nervous System.

DOSIMETRY, EPIDEMIOLOGY AND TOXICOLOGY OF NANOPARTICLES

Epidemiological Evidence for Health Effect Associations with Ambient Particulate Matter; Toxicological Evidence for Ambient Particulate Matter Induced Adverse Health Effects; Inhaled Nanoparticle Dosimetry; Toxicological Plausibility of Health Effects Caused by Nanoparticles; Integrated Concept of Risk Assessment of Nanoparticles.

References

1. Challa S. S. R. Kumar, "Nanomaterials - Toxicity, Health and Environmental Issues", Wiley-VCH publisher, 2006.
2. Nancy A. Monteiro-Riviere, C. Lang Tran, "Nanotoxicology: Characterization, Dosing and Health Effects", Informa healthcare, 2007.
3. D. Drobne, "Nanotoxicology for safe and Sustainable Nanotechnology", Dominant publisher, 2007.
4. M. Zafar Nyamadzi, "A Reference handbook of Nanotoxicology", Dominant publisher,

2008.

Web Links

1. http://amity.edu/aint/A12028.asp
2. http://www.unom.ac.in/index.php?route=department/department/syllabus&deptid=18

SECOND SEMESTER
ELECTIVE – III
NT 205: 3 NANOTECHNOLOGY BUSINESS APPLICATION AND COMMERCIALIZATION
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. Develop qualitative and quantitative understanding to the relevant concepts of nanoscale systems, and revive the responsibilities of distributed economy of such systems.
2. To provide an overview knowledge of economics involved in nanotechnology-based commercialization, and to induce thinking in the direction of nanotechnology-based business market.
3. To address the overall benefits of systems costs, effective strategies, and promote the growth of the learners using various models and detailed analyses

Course Outcomes

1. Can familiar with nano-related business and enables the students how to link scientific knowledge to the business.

OVERVIEW

Introduction – types of nanobusinesses – ease of entry – intellectual property–ethics–risks/dangers – standardization, investors and commercialization centers–business applications – social aspects of nanotechnology

MARKET LANDSCAPE

Nanotechnology landscape and commercially attributable sectors - Tools to map, understand and segment the nanotechnology marketplace–Potential nanotechnology end-users and applications-Global market for nanotechnology products – Attracting venture capital –How to liaise effectively with partners - academy-industry relationship –University and employee's inventions

COMMERCE AND REGULATION

Frameworks for developing nanotechnology marketplace –Incentives for Commercial applications– Shaping the Nanotech Marketplace- Allocating Costs associated with Risks – Public perception of nanotechnology – Critical impact of Regulation of Nanotechnology – Environment, health and safety within the nanotechnology industry–Developments that could influence the nanotechnology market – Impact for Future technologies

BUSINESS STRUCTURES

Relationship b/w technology development and new business creation– the company concepts– new technology–new opportunity– sole proprietorships– general and limited partnerships– professional and closed corporations

MATERIALS PROCESSING ECONOMICS

Comparison and projection of yield– manufacturing o utput– labor and equipment expenses to calculate and estimate costs – relative performance enhancements for materials processing– alternate approaches– Identification of equipment– facilities and overheads – specific manufacturing methods– Tools to estimate the economics of process– Address ing the effect of overall system costs – its benefits

References

1. Sherron Sparks, "Nanotechnology: Business Applications and Commercialization," CRC Press, Taylor & Francis group, London 2012.
2. Jeffrey H. Matsuura" Nanotechnology Regulation and Policy Worldwide" , Artech House; 1 Ed., 2006.
3. "Nanotechnology developments in India – A status repor"t , The Energy and Resources Institute (TERI), India 2009.
4. "Nanotechnology: a Realistic Market Assessment" , Research, Market Forecasting 2006.

5. Michael T. Burke, “Nanotechnology: The Business, Perspectives in Nanotechnology” , CRC Press, Colorado, USA 2008.

Web Links

1. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

SECOND SEMESTER
ELECTIVE – III
NT 205: 4 SOCIAL IMPACTS IN NANOTECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To provide awareness to the engineering students about socio economic impact of nanotechnology and to handle the techniques effectively.
2. To understand the various social impacts of nanotechnology trend and research.
3. To enhance the nanotechnology research by taking ethics and public opinion into consideration.
4. To understand of professional and ethical responsibility.

Course Outcomes

1. One can gain the knowledge on social impact of nanoscience and nanotechnology.

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

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

ECONOMIC IMPACTS AND COMMERCIALIZATION OF NANOTECHNOLOGY & SOCIAL SCENARIOS
Introduction -Socio-Economic Impact of Nanoscale Science: Initial Results and Nanobank-Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria -The Emerging NanoEconomy: Key Drivers, Challenges, and Opportunities-Transcending Moore’s Law with Molecular Electronics and Nanotechnology- Navigating Nanotechnology Through Society -Nanotechnology, Surveillance, and Society: Methodological Issues and Innovations for Social Research-Nanotechnology: Societal Implications: Individual Perspectives-Nanotechnology and Social Trends-Five Nanotech

ETHICS, LAW & GOVERNANCE
Ethics and law-Ethical issues in Nanoscience and Nanotechnology: Reflections and suggestions –Ethics and Nano: A survey-Law in a New Frontier- An Exploration of Patent Matters Associated with Nanotechnology -The Ethics of Ethics -Negotiations over Quality of Life in the Nanotechnology Initiative. Governance-Problems of Governance of Nanotechnology -Societal Implications of Emerging Science and Technologies: A Research Agenda for Science and Technology Studies (STS)-Institutional Impacts of Government Science Initiatives -Nanotechnology for National Security.

PUBLIC PERCEPTIONS & EDUCATION
Public Perceptions-Societal Implications of Nanoscience: An Agenda for Public Interaction Research -Communicating Nanotechnological Risks- A Proposal to Advance Understanding of Nanotechnology’s Social Impacts - Nanotechnology in the Media: A Preliminary Analysis-Public Engagement with Nanoscale Science and Engineering -Nanotechnology: Moving Beyond Risk-Communication Streams and Nanotechnology: The (Re)Interpretation of a New Technology- Nanotechnology: Societal Implications — Individual Perspectives-Historical Comparisons for Anticipating Public Reactions to Nanotechnology.

References

1. Mihail C. Roco and William Sims Bainbridge “Nanotechnology: Societal Implications II-Individual Perspectives”, Springer, 2007.
2. Geoffrey Hunt and Michael D. Mehta “Nanotechnology: Risk, Ethics and Law”, Earthscan/James & James publication, 2006.
3. Jurgen Schulte “Nanotechnology: Global Strategies, Industry Trends and Applications”, John Wiley & Sons Ltd, 2005.
4. Mark. R. Weisner and Jean-Yves Bottero “Environmental Nanotechnology applications and impact of nanomaterial”, The McGraw-Hill Companies, 2007.

Web Links

1. hindustanuniv.ac.in/nano_tech.php
2. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

SECOND SEMESTER
ELECTIVE – III
NT 205: 5 FUEL CELL TECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. Understand the basic principles of Fuel Cell Technology and Micro Fluid System.
2. To give basic knowledge on fuel cell fundamentals including thermodynamics, electrode kinetics, fuel cell performance and transport issues.
3. Familiarizing with the operating principles and chemical reactions of different types of fuel cells.
4. Learning about the applications of fuel cells in transportation and stationary power generation.

Course Outcomes

1. Able to Explore the effect of various parameters on different fuel cell performance.

INTRODUCTION

Fuel cell; brief history of fuel cells, types of fuel cells and fuel cell applications.

THERMODYNAMICS AND ELECTROCHEMICAL KINETICS

Engineering thermodynamics, conversion efficiencies of heat engines and fuel cells, chemical reactions, chemical thermodynamics and electrochemical kinetics.

FUEL CELL COMPONENTS AND THEIR IMPACT ON PERFORMANCE

General design features, fuel cell performance: the MEA and the current/voltage curve, MEA components and the fuel cell stack.

STACK DESIGN

Sizing of a fuel cell stack, stack configuration, uniform distribution of reactants inside each cell, heat removal from a fuel stack and stack clamping.

FUEL CELL MODELING

Theory and governing equations, modeling domains and modeling examples.

FUEL CELL SYSTEM DESIGN

Hydrogen-air system, fuel cell systems with fuel processor, electrical subsystems and system efficiency.

FUEL CELL APPLICATIONS

Transportation applications, stationary power, backup power and fuel cells for small portable power.

References

1. For chapters 1 to 3: Fuel Cell Technology Hand Book, Edited by Gregor Hoogers, CRC Press.
2. For Chapters 4 to 7: PEM Fuel Cells: Theory and practice By Frano, Elsevier Academic Press.
3. Fuel cells principles and applications by B.Viswanathan and M. Aulice Scibioh, Universal Press. (India) Private Limited, Hyderabad.
4. Fuel Cell Systems Explained, second edition, by James Larminie and Andrew Dicks, John Wiley & Sons Ltd.

Web Links

1. http://www.fuelcelltoday.com/media/1637138/fc_basics_technology_types.pdf
2. http://www3.nd.edu/~msen/Teaching/DirStudies/FuelCells.pdf
3. https://www.netl.doe.gov/File%20Library/research/coal/energy%20systems/fuel%20cells/FCHandbook7.pdf
4. http://www.ogniwa-paliwowe.info/download/introduction_to_fuel_cells_and_hydrogen_technology.pdf

SECOND SEMESTER
ELECTIVE – III
NT 205: 6 COMPUTATIONAL NANOTECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To understand the evolution of computing technology and its significance.
2. The objective of this course is to make the students acquire depth of knowledge in the concepts of classical and statistical mechanics and to apply it to different nano scale systems
3. To understand the basic concepts involve in this technology for device architecture and interface engineering at atomic.
4. Demonstrate how simulation can facilitate learning of fabrication process and device designing.

Course Outcomes

1. Can gain the adequate knowledge on Nanoscale computing for emerging technology with potential applications.
2. Able to explore the importance of nanoscale simulation which provides an increased computational speed, power-efficient, reduces the space requirements for interconnects and allows for fundamentally new computing paradigms.

INTRODUCTION
Computational simulation, need for discrete computation.

CLASSICAL MECHANICS
Mechanics of Particles, D'Alembert's principle and Lagrange's equation, variational principles, Hamilton's principle, conservation theorems and symmetry properties, central force problems, virial theorem.

STATISTICAL MECHANICS
Review of probability and statistics, quantum states of a system, equations of state, canonical and microcanonical ensemble, partition function, energy levels for molecules, equipartition theorem, minimizing the free energy, partition function for identical particles, Maxwell distribution of molecular speeds.

ATOMISTIC SIMULATION TECHNIQUES
Molecular Dynamics (MD): Introduction, inter-atomic potential function, Lennard-Jones potential, MD simulation – equilibration and property evaluation, various types of potential functions, computational aspects, introduction to advanced topics.

MONTE CARLO (MC) METHOD
Introduction, Metropolis algorithm, advanced algorithms for Monte Carlo simulations, comparison with Molecular Dynamics.

MESOSCOPIC SIMULATION TECHNIQUES
Lattice Boltzmann Method (LBM): Boltzmann equation, derivation of the hydrodynamic equation from Boltzmann equation, Lattice Boltzmann equation and LBM, applications of LBM.

SCIENTIFIC SOFTWARE FOR CHARACTERIZATION
Simple scientific software using Matlab, Mathematica, mechanics, optics and quantum Mechanics, Atomistix and related software, Introduction to Labview software, Rietveld analysis for X-ray diffraction, Curve fitting analysis.

DISSIPATIVE PARTICLE DYNAMICS (DPD)
Fundamentals of DPD simulations, time step size and noise, repulsion parameter, approximate expressions for transport coefficients. Introduction to Multiscale methods and applications.

References

1. Wolfram Hergert, Computational Materials science, Springer.
2. Multiscaling in molecular and continuum mechanics by G. C. Sih, Springer.
3. R.J. Schilling and S.L. Harris, “ Applied Numerical Methods for Engineers using MATLAB and C”, Thomson publishers, New Delhi, 2004.
4. Handbook of Theoretical and Computational Nanotechnology, M. Rieth and W. Schommers (IIT Patna, IISC Bangalore)
5. Mathematical Methods in the Physical sciences, Mary L. Boas.
6. Finite Element Methods for partial Differenctial Equations, Endre Suli.

Web Links:

1. hindustanuniv.ac.in/nano_tech.php
2. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html
3. http://www.cense.iisc.ernet.in/academics/courses.htm

SECOND SEMESTER
ELECTIVE – III
NT 205: 7 NANOMATERIALS FOR SOLAR ENERGY AND PHOTOVOLTAICS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To make the students familiar with energy storage devices and photovoltaic cells.
2. To familiarize with various processing of energy storage devices.

Course Outcomes

1. Can able to implicit the importance of solar batteries.
2. Able to designing concepts/ aspects of photovoltaic cells.

SOLAR RADIATIONS AS ENERGY AND MECHANISM

Solar radiations as a source of energy and mechanism for its entrapment; Measurements and limits of solar energy entrapment; Flat plate collectors and solar concentrators; Solar energy for industrial process heat (IHP) and design of solar green house; Solar refrigeration and conditioning; Solar thermo-mechanical power.

ENERGY STORAGE DEVICES

Introduction of energy storage/conversion devices, State-of-the art status of portable power sources, Solar/photovoltaic (PV) cells as a source of green energy; Fundamentals, Materials,

DESIGN OF PHOTO VOLTAIC CELLS

Design and Implementation aspects of PV energy generation and consumption; Solar cell technologies (Si-wafer based, Thin film, GaAs based, dye-sensitized, PESC and organic solar cells), Efficiency of solar cells and PV array analysis, Photovoltaic system design (stand alone and grid connected) and applications;

EMPHASIS OF STORAGE BATTERIES

Balance of system (BOS) with emphasis on role of storage batteries; Cost analysis, Case study for performance evaluation and problem identification in wide-spread commercialization of the technology.

References

1. Solar Energy: Fundamentals & Applications; H. P. Garg and J. Prakash; Tata McGraw Hill, 1997.
2. Fundamentals of Photovoltaic Modules and their Applications, G. N. Tiwari, S. Dubey & Julian C. R. Hunt, RSC Energy Series, 2009.
3. Solar Photovoltaics: Fundamentals, Technologies and Applications (2nd ed.), C. S. Solanki, Prentice Hall of India, 2011 (ISBN: 978-81-203-4386-6)
4. Solar Cell Device Physics, Stephen Fonash (2nd ed.), Academic Press, 2010 (ISBN: 978-0-12-374774-7).
5. Energy Storage, R. A. Huggins, Springer, 2010.
6. Handbook of Advanced Electronic and Photonic Materials and Devices: Ferroelectrics & Dielectrics, Vol. 10, H. S. Nalwa (ed.), Academic Press, 2001.
7. Electrochemical Nanotechnology, T. Osaka, M. Dutta, Y. S. Diamand (eds.), Springer, 2010, (ISBN: 978-1-4419-1423-1).
8. Encyclopedia of Nanoscience & Nanotechnology, Vol. 10, H. S. Nalwa (ed.), American Scientific Publishers, 2004.

Web Links

1. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html

SECOND SEMESTER
ELECTIVE - III
NT 205: 8 ADVANCED MECHANICS OF COMPOSITE MATERIALS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To describe what are composite materials and their differences with respect to conventional materials such as metals.
2. To describe the challenges associated with engineering design of composites.
3. Transform material properties between different coordinate systems.

Course Outcomes

1. Can able to predict displacement/stress/strain of lamina and laminates under mechanical and hygrothermal loads of composite materials.
2. One can predict strength and failure of lamina and laminates composed of composite materials under mechanical and thermal loads.

BASIC CONCEPTS AND CHARACTERISTICS
Geometric and Physical definitions, natural and man-made composites, Aerospace and structural applications, types and classification of composites.

REINFORCEMENTS
Fibres – Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibres. Particulate composites, Polymer composites, Thermoplastics, Thermosetts, Metal matrix and ceramic composites.

MICROMECHANICS
Unidirectional composites, constituent materials and properties, elastic properties of a lamina, properties of typical composite materials, laminate characteristics and configurations. Characterization of composite properties.

COORDINATE TRANSFORMATION
Hooke's law for different types of materials, Hooke's law for two dimensional unidirectional lamina, Transformation of stress and strain, Numerical examples of stress strain transformation, Graphic interpretation of stress – strain relations. Off – axis, stiffness modulus, off – axis compliance.

ELASTIC BEHAVIOR OF UNIDIRECTIONAL COMPOSITES
Elastic constants of lamina, relation ship between engineering constants and reduced stiffness and compliances, analysis of laminated composites, constitutive relations.

STRENGTH OF UNIDIRECTIONAL LAMINA
Micro mechanics of failure, Failure mechanisms, strength of an orthotropic lamina, strength of a lamina under tension and shear maximum stress and strain criteria, application to design. The failure envelope, first ply failure, free-edge effects. Micros mechanical predictions of elastic constants.

ANALYSIS OF LAMINATED COMPOSITE PLATES
Introduction thin plate theory, specially orthotropic plate, cross and angle ply laminated plates, problems using thin plate theory.

References

1. Mechanics of Composite Materials/ R. M. Jones/ Mc Graw Hill Company, New York, 1975.
2. Engineering Mechanics of Composite Materials by Isaac and M Daniel, Oxford University Press, 1994.
3. Analysis and performance of fibre Composites/ B. D. Agarwal and L. J. Broutman/ Wiley- Interscience, New York, 1980.

4. Mechanics of Composite Materials/ Second Edition (Mechanical Engineering)/ Autar K. Kaw, Publisher**:** CRC
5. Analysis of Laminated Composite Structures/ L. R. Calcote/ Van Nostrand Rainfold, New York, 1969.
6. Advanced Mechanics of Composite Materials/ Vasiliev &Morozov/Elsevier/Second Edition

Web Links

1. http://www.me.mtu.edu/~mavable/Book/Chap3.pdf
2. https://en.wikipedia.org/wiki/Micromechanics
3. http://www.oceanica.ufrj.br/ocean/cursosead/materiaiscompositos/compositematerials/h_micromechanics.pdf
4. http://www.ae.iitkgp.ernet.in/ebooks/chapter4.html
5. http://home.iitk.ac.in/~mohite/Composite_introduction.pdf

SECOND SEMESTER
ELECTIVE – IV
NT 206: 1 RESEARCH METHODOLOGY - ENGINEERING AND MANAGEMENT STUDIES
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. Gain further insights into formulative, descriptive, explanatory, laboratory simulation research activities
2. Determine the frequency with which something occurs or with which it is associated with something else (diagnostic research, measurements and impact analysis)
3. Familiarized with the research codes, professional ethics and disruptive issues such as plagiarism/scientific-misconducts.
4. Establishing the casual relationship amongst the researchers, industry/academia and society

Course Outcomes

1. Able to search, select and critically analyse research articles and papers
2. Prepare a literature review.
3. Formulate and evaluate research questions.
4. Gain experience with instrument development and data collection methods.

RESEARCH METHODOLOGY
Research methodology – definition, mathematical tools for analysis, Types of research, exploratory research, conclusive research, modeling research, algorithmic research, Research process- steps. Data collection methods- Primary data – observation method, personal interview, telephonic interview, mail survey, questionnaire design. Secondary data- internal sources of data, external sources of data.

SCALES AND MEASUREMENTS
Scales – measurement, Types of scale – Thurstone's Case V scale model, Osgood's Semantic Differential scale, Likert scale, Q- sort scale. Sampling methods- Probability sampling methods – simple random sampling with replacement, simple random sampling without replacement, stratified sampling, cluster sampling. Nonprobability sampling method – convenience sampling, judgment sampling, quota sampling.

HYPOTHESES TESTING
Hypotheses testing – Testing of hypotheses concerning means (one mean and difference between two means - one tailed and two tailed tests), Concerning variance – one tailed Chi-square test.

SAMPLE TESTS
Nonparametric tests- One sample tests – one sample sign test, Kolmogorov-Smirnov test, run test for randomness, Two sample tests – Two sample sign test, Mann-Whitney U test, K-sample test – Kruskal Wallis test (H-Test)

ANALYSIS AND REPORT
Introduction to Discriminant analysis, Factor analysis, cluster analysis, multidimensional scaling, conjoint analysis. Report writing- Types of report, guidelines to review report, typing instructions, oral presentation.

References

1. Kothari, C.R., Research Methodology –Methods and techniques, New Age Publications, New Delhi, 2009.
2. Panneerselvam, R., Research Methodology, Prentice-Hall of India, New Delhi, 2004.

Web Links

1. http://coes.latech.edu/grad-programs/ms_msnt_msnt.pdf
2. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html
3. hindustanuniv.ac.in/nano_tech.php
4. http://www.albany.edu/undergraduate_bulletin/n_eng.html
5. http://web.stevens.edu/nano/courses.php

SECOND SEMESTER
ELECTIVE – IV
NT 206: 2 ADVANCED OPTIMIZATION TECHNIQUES
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To understand the concept of search space and optimality for solutions of engineering problems.
2. To understand some computation techniques for optimizing single and multi variable functions.
3. To carry out various computational techniques for optimizing severable variable functions.

Course Outcomes

1. Understand different types of Optimization Techniques in engineering problems. Learn different programming techniques like general, integral and dynamic programming methods.
2. Learn Optimizations Techniques in single and multi-variables problems.
3. Able to explore nontraditional optimization techniques.

GEOMETRIC PROGRAMMING (G.P)

Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. Primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P), Complementary Geometric Programming (C.G.P)

DYNAMIC PROGRAMMING(D.P)

Multistage decision processes. Concepts of sub optimization and Principal of optimality, computational procedure in dynamic programming calculus method and tabular methods. Linear programming as a case of D.P. and continuous D.P.

INTEGER PROGRAMMING(I.P)

Graphical representation. Gomory's cutting plane method. Bala's algorithm for zero-one programming problem. Branch-and-bound method, Sequential linear discrete Programming, Generalized penalty function method.

Stochastic Programming (S.P.): Basic Concepts of Probability Theory, Stochastic Linear programming.

NON-TRADITIONAL OPTIMIZATION TECHNIQUES

Multi-objective optimization - Lexicographic method, Goal programming method, Genetic algorithms, Simulated annealing, Neural Networks based Optimization.

References

1. Operations Research- Principles and Practice by Ravindran, Phillips and Solberg, John Wiely
2. Introduction to Operations Research by Hiller and Lieberman, Mc Graw Hill
3. Engineering Optimization - Theory and Practice by Rao, S.S., New Age International (P) Ltd. Publishers.
4. Engineering Optimization By Kalyanmanai Deb, Prentice Hall of India, New Delhi.
5. Genetic Algorithms - In Search, Optimization and Machine Learning by David E. Goldberg, Addison-Wesley Longman (Singapore) Pvt. Ltd.

Weblinks

1. https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&sqi=2&ved=0ahUKEwjj09PEu_HJAhVKGo4KHd1nATMQFgggMAA&url=http%3A%2F%2Fwww.nptel.ac.in%2Fcourses%2F105108127%2Fpdf%2FModule_1%2FM1L4_LN.pdf&usg=AFQjCNHoEpxem3bi9ccIqCrGlksXnvG71A&sig2=cnWh7snZLR7HWNPwIVolTg&bvm=bv.110151844,d.c2E&cad=rja

2. http://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/OPTIMIZATION%20METHODS/pdf/Module_1/M1L4slides.pdf
3. https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&sqi=2&ved=0ahUKEwjj09PEu_HJAhVKGo4KHd1nATMQFggqMAI&url=http%3A%2F%2Fwww.springer.com%2Fcda%2Fcontent%2Fdocument%2Fcda_downloaddocument%2F9781447127475-c2.pdf%3FSGWID%3D0-0-45-1293543-p174282666&usg=AFQjCNEoAxW84BDk6GTXW-uyYOHCEAQtmQ&sig2=ofYdiGaKA3KzVoD3-8G9nA&bvm=bv.110151844,d.c2E&cad=rja

SECOND SEMESTER
ELECTIVE – IV
NT 206: 3 COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To impart knowledge about various computational methods of heat transfer and fluid flow and solve Simple fluid flow problems.
2. To recognize the nature of the fluid problem and apply boundary conditions.
3. To design a system or process and simulate to meet desired needs and solves engineering applications.

Course Outcomes

1. Able to understand the steady state 1D, 2D and 3D flow fluids.
2. Ability to select the governing equations for 1D, 2D and 3D conduction fluid flow problems.
3. Able to apply different boundary conditions according to the fluid problem.
4. Acquires knowledge about grid generation processing and applications of CFD.
5. Ability to solve real world problems.

EXPERIMENTAL, THEORETICAL AND NUMERICAL METHODS

Experimental, theoretical and numerical methods of predictions; physical and mathematical classifications partial differential equations; computational economy; numerical stability; validation of numerical results; round-off-error and accuracy of numerical results; iterative convergence, condition for convergence, rate of convergence; under – and over – relaxations, termination of iteration; tridiagonal matrix algorithm; discretization – converting derivatives to their finite difference forms – Taylor’s series approach, polynomial fitting approach; discretization error.

STEADY ONE-DIMENSIONAL CONDUCTION

Steady one-dimensional conduction in Cartesian and cylindrical coordinates; handling of boundary conditions; two – dimensional steady state conduction problems in Cartesian and cylindrical co-ordinates– point-by-point and line-by-line method of solution, dealing with Dirichlet, Neumann, and Robins type boundary conditions; formation of discritized equations for regular and irregular boundaries and interfaces; grid generation methods; adaptive grids.

ONE-, TWO, AND THREE-DIMENSIONAL TRANSIENT HEAT CONDUCTION PROBLEMS

One-, two, and three-dimensional transient heat conduction problems in Cartesian and cylindrical co-ordinates – explicit, implicit, Crank-Nicholson and ADI schemes; stability criterion of these schemes; conservation form and conservative property of partial differential and finite difference equations; consistency, stability and convergence for marching problems; discrete perturbation stability analysis, Fourier or von Neumann stability analysis.

References

1. Anderson, D. A, Tannehill, J. C., and R. H. Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, Second Edition, Taylor & Francis, 1995.
2. Muraleedhar, K. and T. Sundararaja, T. (eds.), Computational Fluid Flow and Heat Transfer, Second Edition, Narosa Publishing House, 2003.
3. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere, 1980.
4. Versteeg, H. K. and W. Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Addison Wesley – Longman, 1995.
5. Hornbeck, R. W., Numerical Marching Techniques for Fluid Flows with Heat Transfer, NASA, SP – 297, 1973.

Web Links

1. http://nitc.ac.in/app/webroot/img/upload/MNT_Curriculum_Syllabus_08_1.pdf
2. hindustanuniv.ac.in/nano_tech.php
3. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf

SECOND SEMESTER
ELECTIVE – IV
NT 206: 4 NANOTECHNOLOGY IN HEALTH CARE
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. Understand the principles behind nanomedicine and understand the applications of Nanomaterials in medicine.
2. Impart knowledge about drug delivery systems.
3. Impart the knowledge to apply the Nanomaterials in different medical applications.
4. Impart knowledge about Nanoscale Diagnostics.

Course Outcomes

1. Able to gain sufficient knowledge on importance nanomaterials in medical field.
2. Employ the underlying concepts in molecular, cellular and organismal basis of life, functioning and malfunctions to design strategies for addressing basic and applied problems in healthcare

NANOTECHNOLOGY FOR DISEASE DIAGNOSTICS

Quantum dot conjugation strategies with DNA-aptamer, Protein and Antibody and FRET/BRET based assays for Cancer, AIDS, tuberculosis and other disease diagnostics; Nanoparticle assisted multiplexed diagnostic assays (Bio-barcode amplification assay, Sandwich DNA assay, Eliza) and point-of care diagnostics (Lateral flow assay).

NANOTECHNOLOGY FOR DRUG DELIVERY

Lipid, polymeric, Hyaluronic acid and heparin functionalized core shell nanoparticle as drug delivery vehicles; Carbon nanotube-based vectors for delivering immunotherapeutics and drugs, Hydrogels for drug delivery, nanoparticle induced Gene delivery for gene therapy.

NANOTECHNOLOGY FOR THERAPY

Nanodrugs for treatment of cancer (abraxane and other drugs); concept of nanodrug-encapsulation, self assembly, controlled release (targeted and triggered release), nanoparticle recovery; modified Ag-nanoparticle for Photodynamic Therapy of cancer; nanoparticle assisted vaccine development; nanoshells for surgical procedures.

NANOMACHINES AND NANOBARCODES, NANOBIOSENSORS

DNA Nanomachines for Molecular Diagnostics-Nanobarcodes Technology - Nanobarcode Particle Technology for SNP Genotyping - Qdot Nanobarcode for Multiplexed Gene Expression Profiling-Biobarcode Assay for Proteins Single-Molecule Barcoding System for DNA Analysis Nanoparticle-Based Colorimetric DNA Detection Method Cantilevers as Biosensors for Molecular Diagnostics –CarbonNanotube Biosensors -FRET-Based DNA Nanosensors. Ion Channel Switch Biosensor Technology - Electronic Nanobiosensors -Electrochemical Nanobiosensors -Quartz Nanobalance Biosensors -Viral Nanosensors –PEBBLE Nanosensors -Microneedle-Mounted Biosensors Optical Biosensors- Nanowire (NW) Biosensors -Nanoscale Erasable Biodetectors

NANOPHARMACEUTICALS

Introduction -Nanobiotechnology for Drug Discovery -Gold Nanoparticles for Drug Discovery -Use of Quantum Dots for Drug Discovery -Nanolasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules -Role of AFM for Study of Biomolecular Interactions for Drug Discovery Nanoscale Devices for Drug Discovery -Nanotechnology Enables Drug Design at Cellular Level Nanobiotechnology-Based Drug Development -Dendrimers as Drugs- Fullerenes as Drug Candidates -Nanobodies Nanobiotechnology in Drug Delivery –Nanoscale Delivery of Therapeutics - Nanosuspension Formulations Viruses as Nanomaterials for Drug Delivery - Nanoparticle-Based Drug Delivery -Trojan Nanoparticles -Self-Assembling Nanoparticles for Intracellular Drug Delivery -Nanoparticle Combinations for

Drug Delivery Liposome’s -Liposome–Nanoparticle Hybrids-Nanospheres-Nanotubes – Nanocochleates-Nanomolecular Valves for Controlled Drug Release-Nanomotors for Drug Delivery.

ROLE OF NANOTECHNOLOGY IN BIOLOGICAL THERAPIES

Introduction - Development of nano medicines – Nano Shells – Nano pores – Tectodendrimers– Nanoparticle drug system for oral administration – Drug system for nasal administration – Drug system for ocular administration – Nanotechnology in diagnostic application. Preformulation Studies: on various dosage forms such as tablets, capsules, suspension, creams, emulsion, Injectables, ophthalmic and aerosols etc. Biomedical nanoparticles – Liposome’s – Dentrimers – Different types of drug loading – Drug release – Biodegradable polymers – Applications Nanobiotechnologies for Single-Molecule Detection -Protease-Activated Quantum Dot Probes - Nanotechnology for Point-of-Care Diagnostics -Nanodiagnostics for the Battle Field - Nanodiagnostics for Integrating Diagnostics with Therapeutics

APPLICATION IN CANCER THERAPY & NANOMEDICINE

Introduction and Rationale for Nanotechnology in Cancer Therapy -- Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems - Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications- Pharmacokinetics of Nanocarrier-Mediated Drug and Gene Delivery - Multifunctional Nanoparticles for Cancer Therapy- Neutron Capture Therapy of Cancer: Nanoparticles and High Molecular Weight Boron Delivery Agents. Nano-Oncology- Nanoneurology- Nanocardiology- Nano-Orthopedics-Nano-Ophthalmology

References

1. Kewal K. Jain,” The Handbook of Nanomedicine” Humana Press, 2008.
2. Zhang, ‘’Nanomedicine: A Systems Engineering Approach”,Pan Stanford Publishing, 2005.
3. Robert A. Freitas Jr., “Nanomedicine Volume IIA: Biocompatibility”, Landes Bioscience Publishers, 2003.
4. The handbook of Nanomedicine by Kewal K. Jain, Humana Press, ISBN: 978-1-60327-319-0.
5. Nanomaterials for Medical Diagnostics and Therapy By Challa Kumar (Editor), Wiley-VCH, ISBN-978-3-527-31390-7.
6. Medical Nanotechnology and Nanomedicine by Harry F. Tibbals, CRC Press (Taylor & Francis, ISBN: 13-978-1-4398-0876-4.

Web Links

1. http://www.masters.nano.upenn.edu/program/courses.html
2. https://www.annauniv.edu/academic_courses/00.%20WS%20-%2025.03.14%20-%20final%20(2.1.15)/05.%20Tech/Nanoscience%20and%20Tech.pdf

SECOND SEMESTER
ELECTIVE – IV
NT 206: 5 NANOTECHNOLOGY INTELLECTUAL PROPERTY RIGHTS AND INNOVATION
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To make the students aware of their rights for the protection of their invention done in their project work.
2. To get registration in our country and foreign countries of their invention, designs and thesis or theory written by the students during their project work and for this they must have knowledge of patents, copy right, trademarks, designs and information Technology Act.
3. Further teacher will have to demonstrate with products and ask the student to identify the different types of IPR's.

Course Outcomes

1. Able to apply intellectual property law principles (including copyright, patents, designs and trademarks) to real problems and analyze the social impact of intellectual property law and policy
2. Work in teams, solve problems and manage time.
3. Analyse ethical and professional issues which arise in the intellectual property law context.
4. Write reports on project work and critical reflect on your own learning.

BACKGROUND

Introduction: the invisible infrastructure of innovation-Intellectual Property Dynamics in Society- The types of Intellectual Property- Patent documentstheconstruction of the patent, face of the patent, conception, body of the patents - The innovation cycle- The rise of the intellectual property system- Balancing the tension between exclusive rights and the accessible domains

BASICS OF MANAGING INTELLECTUAL PROPERTY IN ORGANIZATIONS

The innovation forest: intellectual property rights and how they grow- The ABCDs of intellectual property: flow and infringement of IP rights-the patent system - copyrights-trademarks-trade secrets- The global diversity of innovation communities-The role of the innovation chief.

NANOTECHNOLOGY POLICY AND REGULATION

Understanding Nanotechnology- the industrial structure giving rise to Nanotechnology- Societal and Ethical Implications-Environmental Regulation - National Security and Export Controls-Federal Funding- Conclusions

THE ECONOMIC AND LEGAL FOUNDATIONS

A Brief Digression into Terminology - Understanding Open Source – Credit Unions - Open Source: An Analogy - The Role of Open Source Licenses - Different Types of Open Source Licenses- Law and Code - Intellectual
Property and Market Failure - Evaluating the System

STRATEGIC MANAGEMENT OF INTELLECTUAL PROPERTY

A menu of strategy options, -Evaluating internal resources and the external environment – Placing a financial value on IP assets - Accessing innovations of others - Protecting and enforcing IP rights- Transferring IP rights - Strategies on a Global Stage- Specific IP strategies for different communities- Global challenges

References

1. Michael Golin, "Driving Innovation-Intellectual Property strategies for a dynamic world", Venable LLP, Washington DC, 2008.

2. Van Lindberg, “Intellectual Property and Open Source:-A Practical guide to Protecting code” O’Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, 2008.
3. John C. Miller, Ruben Serrato, “The Handbook of Nanotechnology, Business, Policy, and Intellectual Property Law”, John Wiley & Sons, Inc., New Jersey, 2005.
4. Attorney Richard Stim, “Patents, Copyrights, Trademarks- An Intellectual Property desk Reference”, Berkeley, 2006.

Web Links

1. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf
2. http://www.masters.nano.upenn.edu/program/courses.html

SECOND SEMESTER
ELECTIVE – IV
NT 206: 6 NANOPOLLUTION AND E-WASTE MANAGEMENT
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To learn and understand social impact and health issues of nano pollution caused due to nano-industries.
2. To familiarize with different types of E-waste management

Course Outcomes

1. Able to identify impacts of nano pollutants on environment and E – waste management techniques.

ANALYSES OF NANOPARTICLES IN THE ENVIRONMENT

Compositional Analysis - Single Particle Mass Spectrometer - Particle-Induced X-Ray Emission (PIXE) - Surface Area: Product Characterization and Air Monitoring - The Brunauer Emmett Teller (BET) Method. Epiphaniometer - Aerosol Diffusion Charger - Size Distribution-Electrostatic Classifiers.- Real-Time Inertial Impactor: Cascade Impactors- Electrical Low Pressure Impactor (ELPI) - Dynamic Light Scattering (DLS) - Workplace Air Monitoring-Condensation Particle Counter (CPC) - Surface Area: Total Exposure-Sampling and Analysis of Waters and Soils for Nanoparticles.

ENVIRONMENTAL FATE AND TRANSPORT.

Nature of Nanomaterials in the Environment - Physical Manifestation of Nanomaterials: Particle SizeDistribution and Formation of Mobile Suspensions - Chemical Forces Acting on Nanomaterials - Electrostatic or Coulomb Force-van der Waals Forces - Solvency Force-Implications of Polymorphism - Predicting the Behavior of Nanomaterials in the Environment-Predicting Temporal Reaction Rates: Chain Interactions - Predicting Temporal Reaction Rates: Estimating Particle Affinities - Nanoparticle Affinity and Inter-Particle Force Fields - Coulomb Energy- van der Waals Energy-Prediction of Probability of Product Formation.

POTENTIAL ECOLOGICAL HAZARDS OF NANOMATERIALS

Underlying Principles of Ecological Exposure, Effects, and ―Risk‖-Terrestrial vs. Aquatic Ecosystems - Risk and Hazard – Toxicity – Exposure -Factors That Can Affect the Toxicology of Nanomaterials -Toxicity of Nanomaterials - Exposure to Nanomaterials - Sources and Routes of Exposure - Exposure and Dose - Anticipated Hazards To Terrestrial Ecosystems - Anticipated Hazards to Aquatic Ecosystems - Methodologies for Evaluating Hazards and their Limitations.-Recommendations for Managing the Risks of Future Nanomaterials and their Production.

E-WASTE MANAGEMENT

WEEE – The Scale of the Problem - Legislative Influences on Electronics Recycling - Producer Responsibility Legislation - The WEEE Directive - The RoHS Directive - Other Examples of Legislation - Treatment Options for WEEE - Material Composition of WEEE-Socio-economic Factors - Logistics of WEEE- WEEE – the International Perspective - European Perspective-Japan - Barriers to Recycling of WEEE - The Recycling Hierarchy and Marketsfor Recyclate - WEEE Health and Safety Implications .

INTEGRATED APPROACH TO E-WASTE RECYCLING

Recycling and Recovery Technologies - Sorting/Disassembly-Crushing/Diminution –Separation - Emerging Recycling and Recovery Technologies - Automated Disassembly - Comminution - Separation - Thermal Treatments - Hydrometallurgical Extraction - Dry Capture Technologies - Biotechnological Capture - Sensing Technologies - Design for Recycling and Inverse - Manufacturing - Printed Circuit Boards - Sector-based Eco-design .

References

1. Kathleen S, Christopher M, Lynn L. Bergeson ―Nanotechnology and the Enviroment‖, CRC press (2009).

2. R. E. Hester, R. M. Harrison ―Electronic Waste Management‖, RSC publishing (2009)
3. Darcy J. Gentleman, ―Nano and the Environment: Boon or Bane?" Environmental Science and technology, Vol. 43, (2009).

Web Links

1. http://www.unom.ac.in/index.php?route=department/department/syllabus&deptid=18
2. http://jntuh.ac.in/new/bboard/environmentcourses/envi%20manage.pdf
3. http://www.unishivaji.ac.in/uploads/syllabus/Science/B.Sc.III/B.Sc.%20Environmental%20Nano%20Tech%20&%20Application%20Part-III.pdf

SECOND SEMESTER
ELECTIVE – IV
NT 206: 7 INDUSTRIAL NANOTECHNOLOGY
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To make the students familiar with energy storage devices.
2. To familiarize with various devices like quantum dots, nano computers etc.

Course Outcomes

1. Can able to understand design aspects of an effective data storage devices with the help of nano materials .
2. Able to understand the concepts/ aspects of nano electronic devices.

OVERVIEW OF INFORMATION STORAGE AND NANOTECHNOLOGY

Different types of information storage materials and devices: solid state memory, optical memory, magnetic recording, emerging technologies, role of nanotechnology in data storage.

OPTICAL DATA STORAGE

Write and read techniques (signal modulation, disk format, data reproduction), read and write principles (read-only, write-once, phase-change, magneto optic disks), optical pickup heads (key components, diffraction-limited laser spot, focusing and tracking error signals, servo loop design, actuator), optical media, near field optical recording, holographic data storage.

NANO PHARMACEUTICALS

Generation and significance of Nano pharmaceuticals like Nanosuspension, nanogels, Nanocarrier systems, Nano formulation, Nano-incapsulation, Enhancement of drug therapy epitaxy

INDUSTRIAL APPLICATIONS OF NANOMATERIALS

Nanoparticles and Micro–organism, Nano-materials in bone substitutes & Dentistry, Food and Cosmetic applications, Textiles, Paints, Catalysis, Drug delivery and its applications, Biochips-analytical devices, Biosensors.

NANOELECTRONIC& NANOCOMPUTER ARCHITECTURES AND NANOTECHNOLOGY

Introduction to nanoelectronic and nanocomputers, Quantum DOT cellular Automata (QCA), Single electron circuits, molecular circuits Nanocomputer Architecture.

References

1. Wu YH, “Nano Spintronics for Data Storage”, Encyclopedia for Nanoscience and Nanotechnology, vol.7, American Scientific Publishers, 2003.
2. John Mongilo, “Nanotechnology 101”, Green wood publishing house.
3. Nanoelectronics & Nanosystems: From Transistor to Molecular & Quantum Devices: Karl Goser, Jan Dienstuhl and others.
4. Rainer Waser, ―Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices‖, Wiley-VCH (2003).
5. Paras N. Prasad, Nanophotonics, John-Wiley-Interscience, 2004.
6. Sergey V. Gaponenko, Introduction to Nanophotonics, Cambridge University Press, 2010.
7. Hiroshi Masuhara and Satoshi Kawata, Nanophotonics; Integrating Photochemistry, Optics and Nano/Bio Materials Studies, Elsevier, 2004.
8. Mark L. Brongersma and Pieter G. Kik, Eds., Surface Plasmon Nanophotonics, Springer, 2007.
9. Motoichi Ohtsu, Ed., Progress in Nanophotonics, Springer, 2011.

Web Links

1. https://targetstudy.com/university/108/kurukshetra-university/course/mtech-nano-science-and-technology.html
2. http://www.srmuniv.ac.in/sites/default/files/files/M%20Tech%20Nanotechnology%20curriculum&Syllabus%202012-2013.pdf
3. http://www.iitp.ac.in/index.php/academics/programmes/mtech-postgraduate/course-curriculum/516-nanoscience-and-technology-curriculum.html

SECOND SEMESTER
ELECTIVE – IV
NT 206: 8 NANOTECHNOLOGY IN POLYMERS
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 4 Th. **Ses. : 30 Exam: 70**
Examination (Theory): 3hrs. **Credits: 4**

Course Objectives

1. To give knowledge on polymer based nano materials and its synthesis, fabrication, characterization in brief manner.
2. To demonstrate the different types of polymers for textile and organic electronic applications.

Course Outcomes

1. Can able to understand the aspects of an effective polymer for textile andorganic electronic applications .

INTRODUCTION TO POLYMERIC MATERIAL

Introduction – polymers nanotechnology, origin, classification and formation of polymers, micro structures in polymers – polymer length, molecular weight, amorphous and crystalline, challenges of polymers in nanotechnology – polymers in top – down and bottom – up nanotechnology.

CONDUCTING POLYMERSrganic electronic applications.

General description – poly(acetylene)s – synthesis , structure and morphology- theory of conductivity, Conduction mechanism, uses – poly(pyrrole)s- poly(aniline)s, poly(phenylene)s - polymers with metals in the side group structure.

POLYMER FUNCTIONALITY

Nanostructuring polymers - polymer nanofibers - multifunctional polymer nanocomposite from polymerization - nanofilled polymeric fibers, polymers/clay nanocomposites.

TEXTILE APPLICATIONS

Introduction – electrospinning- production of non woven mat from electrospinning - controlling the parameter and morphology of nanofibers - electro static self assembled nanolayer films nanocomposite fibers – Nanofibers in mask and tissue engineering Applications.

ORGANIC ELECTRONIC APPLICATIONS

Printing and patterning techniques - Nanoscale behavior in organic transistors - transition of sensing response by organic transistor from micro to nanoscale - organic field effect transistor sensor - flexible organic light emitting diode.

References

1. Harry R allcock, Frederick W lampe and James E Mark,” Contemporary polymer chemistry”, person education, 2003.
2. K cousins, keith cousins,” polymers in electronics” smithers Rapra technology publishers, 2006.
3. P J Brown and K Stevens,” nanofibers and nanotechnology in textiles” CRC press, 2007.
4. Frances Gardiner, Eleanor carter,: polymer electronics – a flexible technology”, ismithers, 2009.

Web Links

1. http://elib.uni-stuttgart.de/opus/volltexte/2009/4696/pdf/Applications_of_Nanotechnology_in_the_Polymer_and_Textile_Fields.pdf
2. http://ac.els-cdn.com/S0032386108003157/1-s2.0-S0032386108003157-main.pdf?_tid=3c3926da-ad4a-11e5-a355-00000aacb35f&acdnat=1451297185_3029fcaaeb0a7511c2272bb680b20538
3. http://www.technicaltextile.net/articles/raw-material/detail.aspx?articleid=1006

SECOND SEMESTER
NT 207 – CHARACTERIZATION OF NANOMATERIALS AND NANO STRUCTURES
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 3 **Internal:100**
Credits: 3

Course Objectives

1. To know the importance of the characterization; investigations into the various factors influence the properties of nanomaterials, optimizing the procedures, and implementations to the new designs

Course Outcomes

1. Able to identify the suitable technique for characterization of nano materials and devices experimentally.

1. X-ray Diffraction measurements of Nano Crystallites
2. Nanoparticle size analysis
    a. Scanning Electron Microscopy
    b. Atomic Force Microscopy
    c. Scanning Tunneling Microscopy

References

1. Advanced catalysis and Nano structured material by WR Moser.
2. Introduction to Nano Technology by Charles. P.Poole Jr and Frank J. Owens Wiley India Pvt Ltd.
3. Encyclopedia of Nanotechnology by H.S. Nalwa
4. Nano: The Essentials – Understanding Nano Scinece and Nanotechnology – by T.Pradeep; Tata Mc.Graw Hill

Web Links

1. http://www.jeol.co.jp/en/applications/pdf/sm/sem_atoz_all.pdf
2. https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjs7cOXnoDKAhVVBI4KHazCC0cQFggbMAA&url=http%3A%2F%2Fwww.msrt.ir%2Ffa%2Fshaa%2FDocuments%2FWikiShaa%2FXRD.pdf&usg=AFQjCNGFNSbE9OjtnxqAv02qOBLt46no4w&sig2=3BelZkA_tLyiHkYgndVxNA&bvm=bv.110151844,d.c2E&cad=rja
3. http://www.eng.utah.edu/~lzang/images/Lecture_10_AFM.pdf

SEMESTER
NT 208 SEMINAR
(Four-Semester Course - CBCS- w.e.f. 2015-2016)

Periods/week: 3 **Internal:100**
Credits: 2

Course Objectives

1. The student shall be capable of identifying topics of interest related to the program of study and prepare and make presentation before an enlightened audience.

Course Outcomes

1. Able to prepare and presenting technical topics