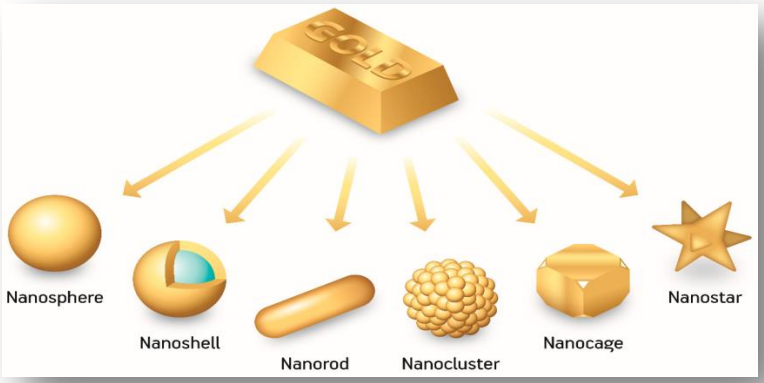
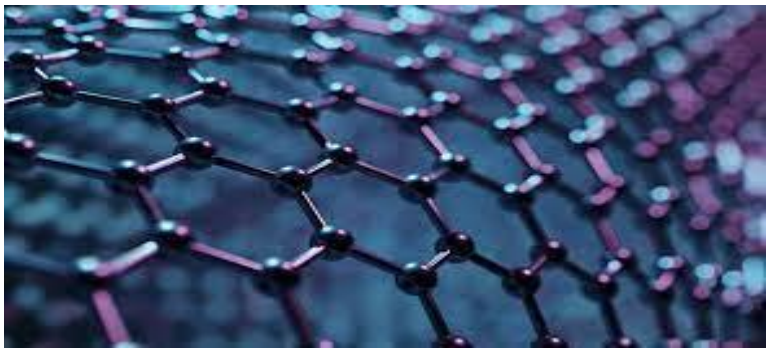
M.Tech Nanotechnology Syllabus

(Approved by 110th Executive Council vide Dated 26th October 2021)





SCHOOL OF NANOTECHNOLOGY
(An Autonomous University Teaching Department)
RAJIV GANDHI PROUDYOGIKI VISHWAVIDYALAYA
(State Technological University of Madhya Pradesh)

Airport Road, Bhopal-462033www.rgpv.ac.in

M.Tech Nanotechnology Syllabus

CURRICULUM OUTLLINE

M. Tech. [NANOTECHNOLOGY]

Core Subject

SEMESTER-I

MNT101	Mathematical Methods and Programming
MNT102	Synthesis of Nanomaterials
MNT103	Mechanics at Nanoscale
MNT104	Materials Science at Nanoscale
MNT105	Characterization of Nanomaterials

SEMESTER-II

MNT201	Properties of Nanostructures
MNT202	Transduction and Measurements
MNT203	(A) Functional Nanomaterials
MNT204	(A) Nanoscale Devices
MNT205	(A) Nanobiotechnology

SEMESTER-III

MNT301	(Elective–IV) Nanoelectronics and Nanophotonics
MNT302	(Elective-V) Environmental Nanotechnology
MNT303	Seminar
MNT304	Dissertation part-I (Literature Review/Problem Formulation/ Synopsis)

SEMESTER-IV

MNT401	Dissertation Part-II (Literature Review/Problem Formulation/ Synopsis/ Defense)

GUIDE LINES FOR PROJECT WORK

- For M. Tech. II year (III & IV Semester) students a project work shall be compulsory.
- The project shall be carried out under the supervision of departmental faculty members or in collaboration with industry / national / international academic institutions.
- The project work shall be of one year duration of one project divided in two semesters III & IV.
- The project synopsis and research methodology in III semester of the same project shall be evaluated by the two external examiners of the national / international repute.
- The seminar based on research paper that is one of the base papers of the same project shall also be evaluated by the external examiner of national/ international standing.
- The candidate shall be required to submit the one project report printed in triplicate after publication of one research and one review article in the peer reviewed journals at the end of the fourth semester/ before obtaining the M.Tech degree.
- There shall be thesis evaluation by external examiner of national / international status.
- After receiving the evaluation report from the concerning examiner, suggestion/s suggested by the concerning examiner (if any) should be incorporated in the thesis.
- Then the candidate shall be eligible for examination and defense / viva-voce of research project at the end of the IV semester.

ATTENDANCE

- Candidates appearing as regular students for any semester examination shall be required to attend at least 75% of lecturers delivered and of the practical's held, separately in each paper, provided that a short fall in attendance up to 5% can be condoned by the Vice Chancellor of Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal respectively for satisfactory reasons.

Note: If a candidate has passed a semester examination in full he/she shall not be permitted to reappear in the examination for improvement of division/marks of any other purpose.

CRITERIA FOR PROMOTION TO HIGHER SEMESTER

According to Ordinance No.8 (A) for degree in Master of Engineering/Technology/Master of Architecture (M.E/M.Tech /M.Arch.) for the Candidates admitted in 1st year on/after July, 2010, under **Credit Based Grading System** applicable from July, 2010, the criteria for promotion to higher semester is as follows:

- For the award of degree minimum Cumulative Grade Point Average (CGPA) required is 5.0.
- To pass a particular subject of the course the minimum required grade is D. However, the candidate should also separately score minimum required of grade D in both mid and end semester examinations of theory and practical parts of the subject individually.
- The distribution of weightage/marks for each component are as following :

Theory Block

i) Quizzes, assignments and regularity	10%
ii) Mid-semester tests	20%
iii) End-semester Examination	70%
Total	**100%**

Practical Block

i) Lab work and performance, quizzes, assignments and regularity	40%
ii) End-semester examination	60%
Total	**100%**

- Project work shall be treated as practical subject.

The grades to be used and their numerical equivalents are as under:

Credit Based Grading System

Grade	**% Marks range (based on absolute marks system)**	**Grade Point**	**Description of performance**
A+	91-100	10	Outstanding
A	81-90	9	Excellent
B+	71-80	8	Very Good
B	61-70	7	Good
C+	51-60	6	Average
C	41-50	5	Satisfactory
D	40 only	4	Marginal
F	Below 40	0	Fail
I		0	Incomplete
W		0	Withdrawal

School of Nanotechnology

(An Autonomous University Teaching Department)

Rajiv Gandhi Proudyogiki Vishwavidyalaya, Airport Road, Bhopal

Programme outcomes (POs), Program Specific outcomes (PSOs) and Course outcomes (COs) of the Programmes offered by the Institution

Programme code	Programme Name	Institution
MT	M. Tech Nanotechnology	School of Nanotechnology

Programme Outcomes (PO'S)

PO 01	An ability to independently carry out research /investigation and development work to solve practical problems
PO 02	An ability to write and present a substantial technical report/document
PO 03	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

Programme Specific Outcomes (PSO'S)

PSO 01	Develop practical knowledge by linking nanotechnology, disciplinary and interdisciplinary aspects.
PSO 02	Acquire knowledge in the nanotechnology domain that enables their applications in industry and research, considering the environmental and societal context into account.

Methods of measuring attainment of PSOs
• Programme specific outcomes are ascertained by periodic review of the teaching and research activities at the institute and presentation of the progress at leading national and international journals as research publications. • Further independent expert reviews and teaching seminars are also conducted for evaluating the teachers and students for keeping the morale and scientific temper and

Course Outcomes

(COs) Semester -I

S.No.	Name of the course	Course Code	Course Outcome
01.	**Mathematical Methods & Programming**	MNT 101	**On successful completion of the course the students will be able to:** • Evaluate the Fourier and Laplace Transform to solve real world problems. • Solve Bessel functions, Hermite and Legendre polynomials and their properties for differential equation solutions. • Compute a conditional probability for an event by using Baye's theorem. • Apply good programming principles to the design and implementation of C++ programs. • Use MATLAB as a simulation tool.
02.	**Synthesis of Nanomaterials**	MNT 102	**On successful completion of the course the students will be able to:** • Use various top-down and bottom-up approaches for nanomaterial synthesis. • Explain lithography techniques for nanomaterial synthesis. • Analyze various deposition techniques at the atomic and molecular level. • Describe structure and properties of thin films. • Synthesis nanomaterial's by various methods.

03.	**Mechanics at Nano Scale**	MNT 103	**On successful completion of the course the students will be able to:** • Use the advanced concepts of quantum theory. • Demonstrate the importance of Schrodinger wave equation & its applications. • Apply the knowledge on quantum confinement effects. • Gain the knowledge in dispersion relation of electron in solids. • Classify the quantum nanostructures, such as quantum dots, nanowires and quantum wells and their density of states.
04.	**Materials at Nano Scale**	MNT 104	**On successful completion of the course the students will be able to:** • Demonstrate crystal structure & atomic bonding in solids. • Classify the materials based on their properties. • Identify different imperfections in solids. • Describe thermodynamics and elementary statistical mechanics. • Apply Magnetic, Optical & Thermal properties of different material for potential applications.
05.	**Characterization of Nanomaterials**	MNT 105	**On successful completion of the course the students will be able to:** • Apply various morphological techniques by selecting appropriate tools for their future research. • Demonstrate various spectroscopic techniques. • Choose Scanning probe techniques for characterization of nanomaterial's. • Analyze advanced microscopic characterization techniques. • Prepare, characterize and analyze the samples with suitable techniques.

06.	**Lab-I**	MNT-106	**On successful completion of the course the students will be able to:** • Correlate properties of nanostructures with their size, shape and surface characteristics. • Synthesize quantum nanostructures of desired size, shape and surface properties. • Explain the principle and working of UV -Vis absorption spectroscopy technique. • Synthesize and deposit nanomaterials by various methods. • Identify the FTIR spectrum ranges of different functional groups
07.	**Lab-II**	MNT-107	**On successful completion of the course the students will be able to:** • Use MATLAB as a simulation tool. • Develop programming skills and technique to solve mathematical problems. • Simulate various application based nanoscale devices. • Use of tools like origin for result analysis. • Analyze results using simulation tools.

Course Outcomes

(COs) Semester –II

S.No.	Name of the course	Course Code	Course Outcome
01.	**Properties of Nanostructure**	MNT-201	**On successful completion of the course the students will be able to:** • Explain various nanostructures and its applications towards Quantum Electronic Devices. • Analyze the thermal and vibrational properties of nanoscale material. • Compare the basics of Micro and nanofluid mechanics and its importance. • Develop the foundations of nanophotonics. • Identify the scope of metamaterial applications.
02.	**Transduction and Measurements**	MNT-202	**On successful completion of the course the students will be able to:** • Explain various micro and nano-sensors with their working. • Apply material's properties used for the fabrication of nano-sensors. • Analyze the theory of light and matter. • Become aware of various types of mechanical, chemical and optical nano-sensing systems. • Compare various laser technology.
03.	**Fuctional Nano Materials**	MNT-203	**On successful completion of the course the students will be able to:** • Apply carbon based nanomaterials for device application. • Use the knowledge on synthesis, characterization and application of Smart materials. • Apply hybrid nanomaterials for various applications. • Demonstrate the potential application of Supramolecules. • Explain the functionalization and applications of CNT & Graphene.

04.	**Nanoscale Devices**	MNT-204	**On successful completion of the course the students will be able to:** • Explain the knowledge of silicon based technology. • Evaluate the limitations of conventional MOSFETs at Nanoscale. • Explain nano- lithography techniques for nano scale device fabrication. • Analyze the fabrication and characteristics of nanoscale devices such as HBTs. • Express the fundamentals of carrier transport in quantum structures.
05.	**Nano Biotechnology**	MNT-205	**On successful completion of the course the students will be able to:** • Apply the basics of molecular biology and its importance in nanobiotechnology. • Analyze the phenomenon of organic nanomaterial & their application in nanotherapeutics. • Explain the role of various nanoparticles in nanobiotechnology applications. • Apply the knowledge about various nano bio devices. • Use the fundamental principles of nanotechnology and their application to biomedical engineering.
06.	**Lab-III**	MNT-206	**On successful completion of the course the students will be able to:** • Use various chemical and physical methods for the synthesis of diverse types of nanomaterial's (0D, 1D and 2D). • Prepare standard solutions in different concentration units: Molarity, Molality and Normality. • Synthesize the nanoparticles in non-aqueous route and observe its luminescence under UV lamp to understand quantum confinement effect. • Synthesize the nanoparticles in aqueous route and study the fluorescence properties of nanoparticles using spectrofluorometer. • Use UV-VIS absorption properties for estimation of particle size.

07.	**Lab-IV**	MNT-207	**On successful completion of the course the students will be able to:** • Use the principles of Dynamic Light Scattering technique in estimating the particle size and zeta potential. • Explain the basics of vibrational spectroscopy (FTIR & Raman) in characterizing samples. • Apply the electrospinning technique and parameters that influence the formation of micro and nano-sized fibers. • Use the thermal and mechanical characterization of polymeric samples. • Apply the basics of XRD in characterizing crystalline and amorphous samples.

Course Outcomes

(COs)Semester-III

S.No.	Name of the course	Course Code	Course Outcome
01.	**Nanoelectronics and Nanophotonics**	MNT-301	**On successful completion of the course the students will be able to:** • Use the knowledge of advanced electronic devices at nanoscale. • Analyze the operation and design of Fin FET based circuits. • Design reliable circuits using nanowire arrays and CNT interconnects. • Explain the knowledge of Quantum Computation. • Use the fundamentals of Spintronics and Nanophotonics.
02.	**Environmental Nanotechnology**	MNT-302	**On successful completion of the course the students will be able to:** • Select development activities, policies and ethical issues involved in nanomaterials research. • Solve research gaps and provide solutions to socio-economic and environmental problems. • Identify the nanotechnology's relevance and frameworks for developing marketing strategy. • Use the knowledge of Indian and World Patent filing procedures. • Expose nano pollutants and its impact on environment and health.

03.	**Seminar**	MNT-303	**On successful completion of the course the students will be able to:** • Develop students' understanding of key communication skills necessary for leadership and participation. • Deliver effective messages based on the analysis of topic, audience, and context. • Collect, analyze, interpret, and present data • Use technology to communicate effectively in various settings and contexts. • Demonstrate appropriate and professional ethical behavior.
04.	**Dissertation part-I**	MNT-304	**Students should be able to:** • Estimate the authority of information from various sources e.g., peer-reviewed journals research articles or magazines. • Organize information systematically and formulate questions for research. • Develop plans and find out the gap in the relevant research area. • Write scientific proposal in the form of synopsis with the relevant outcomes. • Evaluate the methodology for prosed work.

Course Outcomes
(COs) Semester IV

S.No.	Name of the course	Course Code	Course Outcome
01.	**Dissertation part-II**	MNT-401	• Estimate the authority of information from various sources e.g., peer-reviewed journals research articles or magazines. • Organize information systematically and formulate questions for research. • Develop plans and find out the gap in the relevant research area. • Evaluate the methodology and analyze the result for proposed work. • Write technical report with the relevant outcomes.

MNT 101 – Mathematical Methods & Programming

UNIT I :

Theory of transforms: Fourier sine, cosine and complex transforms, transforms of derivatives, convolution theorem, Parseval's relation, momentum representation; example from electromagnetism, Laplace transforms ofsimple function and derivatives, LT solution of ordinary & partial differential equation, convolution theorem.

UNIT II :

Bessel function, Hermite, Legendre & Lagurre polynomials occurrence of special functions andapplications to physical problems.

UNIT III :

Priory and posteriory probability, Bayes theorem, discrete and contineous distribution, correlation and regression analysis, theory of errors, noise power spectral density, techniques ofnoise reduction.

UNIT IV :

C++ programming basics, FOR loops, WHILE loops, DO loops. IF statement, IF ELSE, ELSE IF, BREAK, CONTINUE; Function declaration, calling the function, passing arguments to function, returning values from the function, Array elements, initializing arrays, passing arrays tofunction. Programming for solution of quadraticequations, partial differential equations and matrices.

UNIT V :

Mat Lab programming: symbolic & numerical calculations, graphics, 3D plots, equation solving, matrices, mathematical relations, complex numbers, simplifications, algebraic expressions, mathematical operations, inbuilt functions, differentiation, integration, series, and limits.

References :

1. Mathematcal Physics : Harper
2. Applied Mathematics for Engineers and Physicist : Pipes and Harvil
3. Schaum Series for Vector Calculas, Complex Variables, Transforms and DifferentialEquations
4. Advanced Engineering Mathematics : Kryszik
5. Numerical Recepies in C : The art of Scientific Computing : W.H.Press
6. Robert Lafore: object oriented programming in turbo C++
7. Schuam series: C++ Programing.
8. Computer Programming Language : Addison Wesely
9. Matlab Programming by Rudrapratap Singh
10. Statistical Methods by George W. Snecdecor , William G. Cochran

MNT 102 - Synthesis of Nanomaterials

UNIT I : BULK SYNTHESIS

Top down and bottom up approaches–Mechanical alloying and mechanical ball milling-Mechanochemical process, Inert gas condensation technique – Arc plasma and laser ablation.

UNIT II : CHEMICAL APPROACHES

Sol gel processing-Solvothermal, hydrothermal, precipitation, Spray pyrolysis, Electro spraying and spin coating routes, Self-assembly, self-assembled monolayers (SAMs). Langmuir-Blodgett (LB) films, micro emulsion polymerization- templated synthesis, pulsed electrochemical deposition.

UNIT III : PHYSICAL APPROACHES

Vapor deposition and different types of epitaxial growth techniques (CVD,MOCVD, MBE,ALD)- pulsed laser deposition, Magnetron sputtering - lithography :Photo/UV/EB/FIB techniques, Dip pen nanolithography, Etching process :Dry and Wet etching, micro contact printing.

UNIT IV : NANOPOROUS MATERIALS

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

UNIT V : APPLICATION OF NANOMATERIALS

Overview of nanomaterials properties and their applications, Molecular Electronics and Nanoelectronics – Nanobots- Biological Applications – Quantum Devices – Nanomechanics - Photonics- Nano structures as single electron transistor –principle and design.

References:

1. S.P. Gaponenko, Optical Properties of semiconductor nanocrystals, Cambridge University Press, 1980.
2. W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate(Eds.), Handbook of NanoScience, Engg. and Technology, CRC Press, 2002.
3. K. Barriham, D.D. Vvedensky, Low dimensional semiconductor structures: fundamental and device applications, Cambridge University Press, 2001.
4. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties &Applications , Imperial College Press, 2004.
5. J.George, Preparation of Thin Films, Marcel Dekker, Inc., New York. 2005.

MNT 103 – Mechanics at Nano Scale

UNIT I: INTRODUCTION
Wave-particle duality, Schrödinger equation and expectation values, Uncertainty principle

UNIT II: BASICS OF QUANTUM MECHANICS
Solutions of the one-dimensional Schrödinger equation for free particle, particle in a box, particle in a infinitely deep well potential, linear harmonic oscillator. Reflection and transmission by a potential step.

UNIT III: SOLUTION OF TIME INDEPENDENT SCHRÖDINGER EQUATION
Particle in a three dimensional box, linear harmonic oscillator and its solution, density of states, free electron theory of metals. The angular momentum problem. The spin half problem and properties of Pauli spin matrices.

UNIT IV : APPROXIMATE METHODS
Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels, the variational method, WKB approximation, adiabatic approximation, sudden approximation

UNIT V: QUANTUM COMPUTATION
Concept of quantum computation, Quantum Qbits, Introduction to nuclear spin, quantum confinement, quantum devices, single electron devices.etc,

References :

1. Quantum Mechanics : L.I. Schiff
2. Quantum Mechanics : J.L. Powell and Crasmann
3. Introduction to Quantum Mechanics : Pauling and Wilson
4. Quantum Mechanics : A.K. Ghatak and S. Loknathan
5. The Physics of Low-dimensional Semiconductors: An Introduction , John H. Davies Concepts of Modern Physics, Aurthur Beiser
6. Modern Physics – Beiser 6th edition 2009.
7. Quantum Mechanics - Bransden and Joachen 2nd edition 2000.
8. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, 2nd Edition by Eisberg, Robert; Resnick, Robert, 1985
9. Quantum Physics – Theory and application, Ajoy Ghatak, Springer 2004.

MNT 104 – Materials at Nano Scale

UNIT I: INTRODUCTION OF CRYSTAL

Single crystalline, polycrystalline and amorphous structures, Crystal structure, unit cells, crystal plane, Miller indices, classification of crystal (symmetry group classification), crystal orientation. Imperfection in solids: Grain boundaries their relation to mechanical properties, dislocations in single crystals (linear defects and screw dislocation), imperfection dependent properties of crystals.

UNIT II: NANOCOMPOSITES

Nanocomposites, Nanopolymers, Nanoceramics, flexible nano ceramics, morphology, crystal structures, imperfections, nano phase diagrams, cemented carbides, ceramics for structural, wear and environmental applications. Composites: Composite materials, large particle and dispersion strengthened composites. Polymer matrix, metal matrix and ceramic matrix composites.

UNIT III: LATTICE VIBRATIONS AND THERMAL PROPERTIES OF SOLIDS

LATTICE VIBRATIONS AND THERMAL PROPERTIES OF SOLIDS: Concept of lattice vibrations and thermal heat capacity, classical, Einstein and Debye theories of molar heat capacity and their limitations, Concept of phonons

UNIT IV : SOLID STATE SEMICONDUCTING MATERIAL

SOLID STATE SEMICONDUCTING MATERIAL: Intrinsic semiconductors, doping and extrinsic semiconductors, Simple models for semiconductors, Donor and acceptor levels, p-n junction and rectification, tunneling and resonant tunneling, Hall effect in Semiconductors.

UNIT V: PROPERTIES OF NANOMATERIALS

Elasticity: Stress, strain, elastic and plastic deformation, tensile properties, compressive, shear and torsional deformation, hardness. Electronic and ionic conduction, electron mobility and electrical resistivity, Properties of Nanomaterials: Mechanical properties of Nanomaterial, Electrical properties of Nanomaterials, Optical Properties of Nanomaterials, Thermal Properties of nanomaterials.

References :

1. Introduction to solid state physics: C. Kittel
2. Solid state Physics: A.J.Dekker
3. Materials Science and Engineering: An Introduction by W D Callister
4. Solid state physics by Aschroft & Mermin
5. Elements of X ray diffraction, BD Cullity
6. Nanocomposite Science and Technology, Ajayan, Schadler and Braun

MNT 105 – Characterization of Nanomaterials

UNIT I: INTRODUCTION TO METROLOGY

Concepts of Metrology- Accuracy, precision and reliability; Types of Errors - Systematic Errors and Random Errors, Statistical analysis of errors.

Microscopy Techniques-Optical microscopy; Electron microscopy- Scanning Electron Microscopy, EDX, WDX; Transmission Electron Microscopy; EELS; SPM.

UNIT II: SPECTROSCOPY TECHNIQUES

UV-Vis Spectroscopy, Fourier Transform Infrared radiation (FTIR); photoluminescence; XPS; XAS; XRD; Raman Spectroscopy – Surface enhanced Raman Spectroscopy, Auger electron spectroscopy, Thermo gravimetric analysis (TGA).

UNIT III: BASIC DESIGN OF SCANNING PROBE MICROSCOPES

Scanning Tunneling Microscope: Principles of operation, Quantum Mechanical Tunneling phenomenon in STM, Different modes of operation; STS - Principles of operation, applications.

UNIT IV : ATOMIC FORCE MICROSCOPY

Atomic Force Microscope - Modes of operation of AFM, Advanced Modes of AFM - Force Modulation, Conductive AFM, EFM, MFM, SCM.

UNIT V: NEAR FIELD SCANNING OPTICAL MICROSCOPY

Principles of operation, Different modes of operation, Spectroscopic Applications of NSOM. Magnetic Characterization Principles, Components of SQUID systems, Nuclear magnetic resonance (NMR), Vibrating Sample Magnetometer (VSM).

References :

1. Elements of X-ray diffraction B. D.Cullity
2. Differential Thermal Analysis R.C.Mackenzie
3. Thermal Methods of Analysis W.W.Wendlandt
4. Synthesis, Functionalization and Surface treatment of Nanoparticles :Maric Isbella and Buraton
5. Encyclopedia of Nanotechnology : H.S. Nalwa
6. Introduction to Nanotechnology : Charles P. Poole Jr and Frank J. Owens
7. Nanomaterial Systems Properties and Application: A.S.Eldestein and R.C.Cammarata.
8. Handbook of Nanotechnology : Bhushan (Ed), Springer Verlag, New York (2004).

MNT 201 - Properties of Nanostructure

UNIT I :

Nanoscale I/V: Quantum wells, Q wires and dots, density of states, electrical transport properties in semiconductor nanostructures, quantization of conductance, coulomb blockade, Kondo effect, ballistic transport, non-relativistic dirac fermions (massless electrons) & their conductance, Quantum Hall effect, fractional Q Hall effect.

UNIT II :

Vibrational and thermal properties of low-dimensional materials, phonons, quantization of phononmodes, 0D,1D, 2D, and 3D phonons, heat capacity and thermal transport at nanoscale.

Superconductivity phenomena, flux quantization, Josephson effects, proximity and anti proximityeffects at nanoscale.

UNIT III :

Nanofluid mechanics; flow of nanofluid, electrophoresis dielectrophoresis: Size selective sepration of dielectric nano particles, nano and micro fluid channels, low reynold number fluid dynamics, optical tweezer.**Unit IV :**

Linear and nonlinear optical properties, Size Quantization effect, Optical blueshift phenomenon, Effective

mass approximation, Tight Binding Theory (TBT), Collective oscillation, surface plasmon resonance, interactions between Nanoparticles, coupled-dipole approximation, Light detection in nano- structures; scanning near-field microscopy, single-molecule detection.

UNIT V :

Negative refrective index metamaterials, Passive microwave devices and antenna transmission lines metamaterials, super resolving metamaterials, negative refractive index lenses. Plasmonic nanowire metamaterials.

References :

1. Hari Singh Nalwa : Encyclopedia of Nanotechnology
2. Introduction to Nanotechnology : Charles P. Poole Jr and Franks J. Qwens
3. Microwave Properties of Magnetic Films : Carmine Vittoria
4. Physics of Magnetism : S. Chikazumi and S. H. Charap
5. Physical theory of Magnetic Domains : C. Kittel
6. Magnetostriction and Magnetomechanical Effects : E.W.Lee
7. Nanostructures : Bastard
8. The Physics of Low-dimensional Semiconductors: An Introduction , John H. Davies
9. Transport in nano structure: Devid Ferry
10. Electronic transport in meso-scopic systems: Supriyo Datta
11. Nanofluids: Science and Technology by Sarit K. Das.
12. Surface-Enhanced Raman Scattering Physics and Applications Series: Topics in Applied Physics , Vol. 103 Kneipp,
13. Atomic Force Microscopy, Scanning Nearfield Optical Microscopy and anoscratchingApplication to Rough and Natural Surfaces Series: Nano Science and Technology Kaupp, G.

14. Quantum transport: Supriyo Datta
15. Negative refractive index metamaterials; Fundametals applications by GV Eleftheriadas and KBalmain.
16. Physics and applications of negative refractive index metamaterials by S Anantha Ramakrishna
17. Nanofluids: Science and Technology by Sarit K. Das, Stephen U. Choi, Wenhua Yu, and T. Pradeep
18. Fluid Properties at Nano/Meso Scale: A Numerical Treatment (Microsystem and Nanotechnology Series) by Peter Dyson, Rajesh Ransing, Paul H Williams, and Rhondri Williams

MNT 202 - Transduction and Measurements

Unit-I

Principles of transduction; some examples of transducers. Light sensing detectors (photo diodes and photo multiplier tubes) and their classification. Oscilloscopes, fast amplifiers, lockin amplifiers, Controlsystems, interfacing for data acquisition and processing.

Unit-II

Nanosensors: Gas sensors, Pollution sensor, Photo sensor, Temperature sensor, IR detector, Biosensor, nanomaterial gas discharge devices, CNT based fluid velocity sensor. Turbo and ultra high vacuum, Cleanroom technology, class 1000,100,10 clean rooms.

Unit-III

Thermodynamics & liquefaction of gases, Cryostat design , Transport Phenomenon, Fermi surface, Conductivity of solids, Technique of low temperature measurement, Physical properties measurement systems (Quantum design-PPMS), Magnetic properties measurement systems (MPMS), SQUIDS, Vibrational sample magnetometer (VSM), AC magnetic susceptibility measurement. Kelvin probe measurements, Ferroelectric and Ferromagnetic measurement, dielectric measurement.

Unit-IV

Interaction of radiation with matter, absorption, spontaneous emission and stimulated emission, population inversion, Semiconducting lasers, Quantum well lasers and quantum dot lasers. Chaotic lightand coherence, Trapping and cooling.

Unit-V

Scattering theory, elastic and inelastic scattering, Types of scattering (Raman and Rayleigh scattering), Theory of luminescence, types of luminescence, Photoluminiscence, electroluminescence, and its applications, activators and co-activators, colour centres, Single and two photon laser induced fluorescence, excited state dynamics (lifetimes), fluorescence resonant energy transfer, single moleculedynamics.

References :

1. Instrumentation : Sawney
2. Light & Matter : Yehuda Band
3. Laser technology : A. Ghatak
4. NanoPhotonics : Paras N. Prasad
5. Manuals of Quantum design Instruments (ttp://www.qdusa.com/products/ppms.html)Handbook of Thin Film Technology by Leon I. Maissel and Reinhard Glang

MNT 203 - Fuctional Nano Materials

Unit I : INTRODUCTION OF CARBON MATERIALS

Nature of carbon bonds, Different allotropes of carbon, structure and properties of C60, Graphene, Carbon nanotubes and its types, Laser vaporization techniques, arc discharge method and chemical vapor deposition techniques for CNT preparation, purification techniques. Properties of Carbon Nanotubes and Graphene: Optical, Electrical and electronic properties, Mechanical, Thermal and vibrational properties.

Unit II : SHAPE MEMORY ALLOYS AND ITS APPLICATIONS

Shape memory alloys, Principle of one-way and two-way shape memory alloys. Important parameters in pseudo-elastic transformations. Shape memory alloy deformation, twinning & actuation. Thin film shape memory alloys for MEMS and transduction applications.

Unit III : BIOMIMETIC MATERIALS & ITS APPLICATIONS

Biomimetic nanomaterials - introduction to biomimetics, mimicking mechanisms found in nature, synthesis and applications of bioinspired nanomaterials and self-assemblies.

Unit IV : HYBRID NANOMATERIALS

Hybrid nanomaterials, Core shell and other encapsulated systems, magnetic particle ferrites, microorganisms for synthesis of nanoparticles, nanoparticle-enzyme hybrids, Functionalization of carbon nano tubes, covalent functionalization, defect functionalization, nanotube-polymer composites.

Unit V : APPLICATIONS OF CNTS

Applications of Carbon Nanotubes in field emission, fuel cells, CNT FETs, Light emitting displays and flat panel displays, hydrogen storage, solar panels, Application of functional nanomaterials in cleanenergy (Hydrogen Production from Biomass, Catalytic coal hydrogasification), in environmental technologies (clean water and air) and in health care (tissue and bone repairs, bio medical sensors)

References :

1. Nanocomposite Science and Technology, Ajayan, Schadler and Braun
2. Fullerene & Carbon nanotubes, Dressel Shaus
3. Carbon Nanotubes, Elizer
4. Physical properties of CNT: Saito
5. Carbon nanotechnology: Liming Dai
6. Nanotubes and nanowires: CNR Rao and Govindaraj RCS Publishing.
7. Electroceramics: Materials, Properties, Applications, by A.J. Moulson and J.M. Herbert.
8. Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration andAcoustic Emission Sensors,Materials and Amplifiers by G. Gautschi.

9. Smart Structures and Materials, by Artech B. Culshaw.
10. Functional and Smart Materials Structural Evolution andStructure Analysis, by Zhong LinWang and Z. C. Kang.
11. Block Copolymers in Nanoscience by Massimo Lazzari
12. Supramolecular Chemistry, Jonathan W. Steed, Jerry L. Atwood

MNT 204 - Nanoscale Devices

Unit I : BULK NANOSTRUCTURED MATERIALS

BULK NANOSTRUCTURED MATERIALS: Quantum wells, wires and Dots – Size and dimensionality effects, Carbon nanotubes (CNTs)- Single walled carbon nanotubes (SWNTs), Multi walled carbon nanotubes (MWNTs), Graphenes, Fullerenes- Structure and Properties, Metal/oxide nanoparticles, Nano rods, Nanowires, Nanotubes, and Nano fibres, Semiconductor Quantum Dots- Excitons, Magnetic Nanoparticles- Nanostructured Ferromagnetism, Polymer nanoparticles, Core-Shell Structures, Nano crystals, Single electron tunnelling – Applications.

Unit II : GAS SENSING MATERIALS

GAS SENSOR MATERIALS: Criteria for the choice of materials, Experimental aspects – materials, properties, measurement of gas sensing property, sensitivity; Discussion of sensors for various gases, Gas sensors based on semiconductor devices.

Unit III : NANOLITHOGRAPHY

Top down approach to nanolithography; Tools for nanolithography, immersion lithography, Electron and ultraviolet (EUV) photolithography, phase shifting masses, x ray lithography including plasma xray sources, Ebeam lithography, focused ion beams. Nanosphere lithography – Molecular self-assembly, soft lithography, Stereo-lithography, nanoscale 3D shapes – NEMS design, molecular manipulation by STM and AFM - LB flim resists - nanopattern synthesis – Nano scratching.

Unit IV : SEMICONDUCTOR NANODEVICES

SEMICONDUCTOR NANODEVICES-I: Single Electron devices- Nano scale MOSFET – Resonant Tunnelling Transistor – Single Electron Transistors manipulation Single Electron Dynamics Mechanical Molecular Nano robotics Nano devices and Nano computers : Theoretical Models, Molecular Devices Micro and Optical Fibres DNA Based nano devices.

Unit V: MICROFABRICATION AND VLSI TECHNOLOGY

MICROFABRICATION & VLSI TECHNOLOGY - Micro fabrication techniques, MEMS, Microfulidic devices, MOS transistor, NMOS, PMOS, CMOS, VLSI design issues, VLSI design techniques, BIOSENSORS: Principles- DNA based biosensors – Protein based biosensors – materials for biosensor applications- fabrication of biosensors - future potential.

References:

1. VLSI Technology, S M Sze
2. VLSI fabrication, by S K Gandhi
3. ULSI Devices, Wiley New York, by C.Y. Chang and S.M. Sze.
4. Handbook of Semiconductor Manufacturing Tech by R. D. Doering and Y. Nishi.
5. Semiconductors, 2nd edition, Cambridge University Press, by R.A. Smith.
6. Fundamentals of Modern VLSI Devices, Y Taur, and T. H. Ning.
7. Nitride Semiconductors and Devices (Springer Series) by Hadis Morkoç

8. Physical Properties of III-V Semiconductor Compounds: InP, InAs,GaAs, GaP, InGaAs, andInGaAsP by Sadao Adachi
9. Handbook of Compound Semiconductors: Growth, Processing, Characterization, and Devices(Materials Science and Process Technology Series) by Paul H. Holloway and Gary E. McGuire

MNT 205 - Nano Biotechnology

Unit I: BASIC CELL BIOLOGY

Basic concepts of cell and molecular biology, Biomolecules and its structure, Cell cycle and cell division (Mitosis and Meiosis), Factors affecting cell growth (Prokaryotes - Bacteria and Eukaryotes – Somatic Cells), Stem cells - types and their applications. Cancer and its types (carcinoma, sarcoma, melanoma, lymphoma, and leukemia), Cell staining and imaging (Gram staining, Fluorescence staining), cell sorting and counting (FACS – its principle and instrumentation), Cell – Nanostructure interactions.

Unit II: BIOMOLECULES

Biomolecular Structure and Stability. Biopolymers: DNA: structure, geometry, topology, properties of DNA, Recombinant DNA technology. Proteins: enzymes and structural proteins; lipids: fatty acids, phospholipids, glycolipids, protein-lipid assembly and biomimetic nanostructures- lipid nanoparticles, Organic nanomaterials: Dendrimers, micelles, liposomes, block copolymers.

Unit III: NANO-BIOMEDICAL APPLICATIONS

Metallic and ceramic implant materials: Bone regeneration, Nano crystalline structures of Bone and Calcium phosphate cements. Cobalt-based alloys; Titanium and its alloys, Nanoparticles relating to Aluminium oxides; Hydroxyapatite; Glass ceramics; ceramic implants; Carbon implants. Nano dental materials.

UnitIV: NANO-BIOSENSOR

Rationale of Nanotechnology for molecular diagnostics, Bio-functionalization methods, Nanoparticles like Gold, Quantum Dots, and Magnetic Nanoparticles in diagnostics, Bio- nanohybrids-with relevant applications. Nanopore technology, Nano arrays. Nanobiosensors: cantilever, carbon nanotube, nanowires. Pathogen detection by magnetic nanoparticle-based techniques. Nanobiotechnological applications in Environment and Food - detection and mitigation of pollutants and adultrants. Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept.

Unit V: NANOTHERAPEUTICS

Introduction to nanomedicine, nanocapsules, nanorobots, nanopharmacology. Drug designing and synthesis of nanodrugs–metal nanoparticles and drug delivery vechicles– Nanoshells– Tectodentrimers Nanoparticle drug systems – Diagnostic applications of nanotechnology. Safety concerns - Health Risks, and Challenges of nano-bio-products.

References:

1. SV Bhat, Biomaterials (2nd Edition), Narosa Publishing House, New Delhi-2005.
2. JB Park, Biomaterials Science and Engineering, Plenum Press, New York, 1984 ChallaS.S.R.Kumar, Joseph Hormes, Carola Leuschmal.
3. Nanofabrication towards biomedical applications wiley –VCHVerlag GmbH& CO, KGaA.
4. Introduction to Bioinformatics. Lesk L.A. (ed) 2003. Oxford University, Press
5. Encyclopedia of Nanoscience & Nanotechnology : Native, Hari Singh (Ed), AmericanScientific Publisher California (2004).
6. Springer Handbook of Nanotechnology Bhushan, Bharat (Ed.)
7. Nano biotechnology: Concepts, Applications and Perspectives by Christof M.
8. Niemeyer and Chad A. Mirkin
9. Nanobiotechnology C M Niemeyer, C A Mirkin,

10. Biofunctionalization of Nanomaterials, Challa Kumar.
11. Bio inorganic Hybrid Nanostructures, Ruiz-Hitzkey and Yuri Lvov.
12. Biomedical Applications of nanotechnology, Leslie-Peleckey.
13. Targetted Drug & Delivery System : S.P. Vyas
14. Chemical sensors and biosensors, Brian R Eggins
15. Electrochemical methods : Fundamentals and applications by Allen J Bardand Larry Faulkner
16. Springer series on chemical sensors and bio sensors by Viladimir Mirsky
17. Exercises in Synthetic Organic Chemistry by Chiara Ghiron , RussellThomas

MNT 301 - Nanoelectronics and Nanophotonics

UNIT I :

Organic Semiconductors, organic light emitting devices(OLEDs), self assembly of complex organic molecules, molecular switches, thermochromic switches, Motor molecules and bio-mimetic components, charge transfer complexes, molecular
connections, contact issues, conducting polymers, light emitting polymers, polymerpolymer heterostructures, plastic FETs, photodiodes & solar cells, electronic paper,
ink jet printing,.

UNIT II :

Materials and Fabrication techniques of Photonic bandgap Crystals: Semiconductors, amorphous and polymers, fabrication of photonic crystal structure (1D, 2D, 3D), optics in nano sized quantum wells and wires (periodic nanostructures), negative refractive index, microwave induced transport. Nano-scale photonic devices, couplers, waveguides. liquid crystals and their applications at the nanoscale.

UNIT III :

Introduction to nanocomputer architectures, quantum dot cellular automata (QCA), single electron circuits,molecular circuits, application of Quantum mechanical systems for computation. Properties ofQ bits, Quantum circuit model, Quantum gates, Controlled U & NOT gates, Superdense coding.

UNIT IV :

Nanostructure magnetism, effect of bulk nanostructuring of magnets, Giant magneto resistance effect (GMR), Anisotropic magneto resistance (AMR) and Colossal magneto resistance (CMR), Magnetic multilayered thin films and nanowires, super paramagnetism and ferromagnetism in semiconducting quantum dots.

UNIT V :

Spintronics: spin glasses, magnetism in metals, spin density waves, Spin polarized transport, Kondo effect, Kubo effect, Spin valve effect, spin relaxation and injection, Spintronics memory devices and applications, magnetic dipole diodes, magnetic tunneling devices, spin diodes, spin filters and spin transistors, spin Hallbars, spin Qbits.

References :

1. Detection of optical and Infrared Radiation, Kingston & Mac Adam
2. The Handbook of Photonics by Mool Chand Gupta,John Ballato
3. Optical properties of photonic crystals- K.Sakoda
4. Applied Photonics by Chai Yeh
5. Silicon Photonics: An introduction by Graham T.Reed, Andrew p. Knights
6. Introduction to Nanotechnology : Charles P. Poole Jr and Franks J. Qwens
7. Nanotechnology, Kohlr, Michacl.
8. An Introduction to Quantum Computing Phillip Kaye, Raymond Laflamme, Michele Mosca
9. The Physics of Quantum Information: Quantum Cryptography, Quantum Teleportation, QuantumComputation by Dirk Bouwmeester, Artur K. Ekert, Anton Zeilinger
10. Problems And Solutions in Quantum Computing And Quantum Information Yorick Hardy Willi-Hans Steeb
11. Physics theory of Magnetic domains, C Kittel
12. Physics of Magnetism, S Chikazumi and SH Charap
13. Nanomagnetism: Topics in Applied Physis (Springer Tracts)

14. Third generation photovoltaics, Advanced Solar energy conversion, Springer series in photonicsby MA Green
15. Spintronics Fundamentals and applications, by Igor Zutic and SD Sarma.
16. Introduction to spintronics by Supriyo Bandhopadhyay
17. Spin electronics by David D Awschalom

MNT 302 Environmental Nanotechnology

UNIT I

Nanotechnology Roadmap, Nano- scale research and development activites: Policy, ethics and communications. Relationship between universities, research centers, industry and government for nanotechnology, Public understanding of nanoscience, need for dialogue and debate on nanotechnology, role of mass media: journalist, and broadcasters.

UNIT II

Kinds of policy responses to nanotechnology at national, European and international level. Ethical issues involved in nanomaterials research like data sharing, employer responsibilities, risks management.
Social and political interests, values and institutions affected by, and shaping, nanoscale developments.

UNIT III

Marketing in nanotechnology: Understanding and surveying the market place, identifying the nanotechnology's relevance and frameworks for developing commercialization strategy.

UNIT IV

Intellectual property issues associated with nanotechnology andwith technologies developed through large scale multidisciplinary partnerships. Indian and World Patent filing procedures.

UNIT V

Enviromental and social impacts of nanotechnology, health and safety isssues. Nanoparticles in aquatic and terrestrial environments, Nanoparticles in atmosphere. Toxicological properties of nanoparticles and nanotubes, Development of Safe Nanotechnology.

References

1. Nanotechnology: Consequences for human health and theenvironment by R.E. Hester, R.M. Harrison
2. A Comprehensive Guide to the Hazardous Properties of Chemical Substances by Pradyot Patnaik.
3. Societal Implications of nanotechnology by Winner and Langdon.

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