M.Tech. (Nanotechnology)

Course Structure and Syllabus

(Based on Choice Based Credit System)

2018-19 onwards

IK Gujral Punjab Technical University, Kapurthala

IK Gujral Punjab Technical University

VISION

To be an institution of excellence in the domain of higher technical education that serves as the fountainhead for nurturing the future leaders of technology and techno- innovation responsible for the techno-economic, social, cultural and environmental prosperity of the people of the State of Punjab, the Nation and the World

MISSION

- To provide seamless education through the pioneering use of technology, in partnership with industry and society with a view to promote research, discovery and entrepreneurship and
- To prepare its students to be responsible citizens of the world and the leaders of technology and techno-innovation of the 21st Century by developing in them the desirable knowledge, skill and attitudes base for the world of work and by instilling in them a culture for seamlessness in all facets of life.

OBJECTIVES

- To offer globally-relevant, industry-linked, research-focused, technology- enabled seamless education at the graduate, postgraduate and research levels in various areas of engineering & technology and applied sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global technological needs, is motivated to give its best and is committed to the growth of the Nation;
- To foster the creation of new and relevant technologies and to transfer them to industry for effective utilization;
- To participate in the planning and solving of engineering and managerial problems of relevance to global industry and to society at large by conducting basic and applied research in the areas of technologies;
- To develop and conduct continuing education programmes for practicing engineers and managers with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core competence of the University;

- To develop strong collaborative and cooperative links with private and public sector industries and government user departments through various avenues such as undertaking of consultancy projects, conducting of collaborative applied research projects, manpower development programmes in cutting-edge areas of technology, etc;
- To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit;
- To provide leadership in laboratory planning and in the development of instructional resource material in the conventional as well as in the audio- visual, the video and computer-based modes;
- To develop programmes for faculty growth and development both for its own faculty as well as for the faculty of other engineering and technology institutions;
- To anticipate the global technological needs and to plan and prepare to cater to them;
- To interact and participate with the community/society at large with a view to inculcate in them a feel for scientific and technological thought and endeavour; and
- To actively participate in the technological development of the State of Punjab through the undertaking of community development programmes including training and education programmes catering to the needs of the unorganized sector as well as that of the economically and socially weaker sections of society.

ACADEMIC PHILOSOPHY

The philosophy of the education to be imparted at the University is to awaken the **"deepest potential"** of its students as holistic human beings by nurturing qualities of self-confidence, courage, integrity, maturity, versatility of mind as well as a capacity to face the challenges of tomorrow so as to enable them to serve humanity and its highest values in the best possible way.

M.Tech. (Nanotechnology)

Duration: 2 Years (Semester System)

This M.Tech (Nanotechnology) Program includes various core, electives, and other interdisciplinary courses. The diverse lab experiments allow students to understand the fundamental aspects of the subject. A choice of advanced elective courses offers a glimpse in the frontier areas of research and allow students to work on one-year research project as an integral part of their M.Tech (Nanotechnology) programme. The programme also provide adequate exposure to the students for pursuing higher education in the field of technology and Physics (Ph.D.) and other job opportunities in academia and industry.

PROGRAM EDUCATIONAL OBJECTIVES: The Program Educational Objectives are the knowledge skills and attitudes, which the students have at the time of post-graduation. At the end of the program, the student will be able to:

PEO1	Apply the scientific knowledge of Physics, Mathematics, Chemistry, and Engineering for deeper understanding of the matter at nanoscale.
PEO2	Identify, formulate, research literature, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PEO3	Design solutions for advanced scientific problems and design system components or processes.
PEO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PEO5	Create, select, and apply appropriate techniques, resources, and modern scientific and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PEO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional scientific practice.
PEO7	Communicate effectively on complex Scientific/Technological activities with the Scientific/engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PEO8	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Apply principles of basic science concepts in understanding, analysis and prediction of matter at Nano scale.
PO2	To introduce interdisciplinary subjects/concepts/ideas for interdisciplinary application of Science and engineering concepts.
PO3	To introduce advanced ideas and techniques required in emergent area of nanotechnology.
PO4	To develop human resource with specialization in theoretical and experimental techniques required for career in academia and Nano technology driven industry.
PO5	Engage in lifelong learning and adapt to changing professional and societal needs.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

PSO1	Understand and apply principles of physics, chemistry and engineering for understanding the scientific phenomenon in nano domain.
PSO2	Understand and apply mathematical techniques for describing and deeper understanding of nano systems.
PSO3	Understand and apply quantum mechanical methods for particles in various physical systems and processes.
PSO4	Understand and apply inter-disciplinary concepts and computational simulation for understanding and describing the natural phenomenon.
PSO5	Understand and apply principles of quantum mechanics for understanding the nano systems in quantum realm.
PSO6	Provide exposure in various specialization of Nanotechnology
PSO7	Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of phenomenon at nano scale and nano systems.
PSO8	Engage in research and life-long learning to adapt to changing environment.

Semester-I

Sr.No.	Course Code	Course name	Type of Course	Load Allocation			Total Marks	Credits
				L	T	P		
1	MTNT5110-18	Quantum Mechanics	**C**	**3**	**1**	**-**	**100**	**4**
2	MTNT5111-18	Mathematical and statistical Methods at nanoscale	**C**	**3**	**1**	**-**	**100**	**4**
3	MTNT51XX	Elective-I	**E**	**3**	**1**	**-**	**100**	**4**
4	MTNT51XX	Elective-II	**E**	**3**	**1**	**-**	**100**	**4**
5	MTNT5112-18	Numerical Methods Lab	**C**	**-**	**-**	**4**	**50**	**2**
6	MTNT5113-18	Synthesis of Nanomaterial Lab	**C**	**-**	**-**	**4**	**50**	**2**
7	MTNT5114-18	Research Methodology and IPR	**A**	**2**	**-**	**-**	**50**	**2**
8	MTNT51XX	Audit Course -1	**A**	**2**	**-**	**-**	**-**	**-**
		TOTAL		**16**	**4**	**8**	**550**	**22**

C: Core Course; A: Audit Course; E: Elective Course

Electives

Elective-I		Elective-II	
MTNT5116-18	Advanced Material Science	MTNT5120-18	Optical Properties Of Nanomaterials
MTNT5117-18	Elements of Physical Chemistry	MTNT5121-18	Nano Electronics
MTNT5118-18	Processing and Properties of Nanostructured Materials	MTNT5122-18	Nanomaterials, Surface Interface and Catalysis
MTNT5119-18	Solid State Physics	MTNT5123-18	Synthesis and Characterization of Nanomaterials

Semester-II

Sr.No.	Course Code	Course name	Type of Course	Load Allocation			Total Marks	Credits
				L	T	P		
1	MTNT5210-18	Physics and Chemistry of Nanomaterials	C	3	1	-	100	4
2	MTNT5211-18	Nano biotechnology	C	3	1	-	100	4
3	MTNT52XX	Elective-III	E	3	1	-	100	4
4	MTNT52XX	Elective-IV	E	3	1	-	100	4
5	MTNT5212-18	Characterization of Nanomaterials Lab	C	-	-	4	50	2
6	MTNT5213-18	Material Simulation Lab	C	-	-	4	50	2
7	MTNT5214-18	Mini Project	C	-	-	4	50	2
8	MTNT52XX	Audit Course -2	A	2	-	-	-	-
		TOTAL		14	4	12	550	22

C: Core Course; E: Elective course; A: Audit Course

Electives

Elective-III		Elective-IV	
MTNT5217-18	Carbon Nanostructures and Applications	MTNT5221-18	Cellular Biochemistry
MTNT5218-18	Nanostructured Materials for Clean Energy	MTNT5222-18	Bio safety And Hazards of Nano Materials
MTNT5219-18	Nanotoxicology	MTNT5223-18	Advanced Drug Delivery Systems
MTNT5220-18	Imaging Techniques for Nanotechnology	MTNT5224-18	Structures, Spectra and Properties of Biomolecules

Semester-III

Sr.No.	Course Code	Course Name	Type of Course	Load Allocation			Total Marks	Credits
				L	T	P		
1	MTNT531XX	Elective-V	**E**	**3**	**1**	**-**	**100**	**4**
2	MTNT531XX	Open Elective	**OE**	**3**	**1**	**-**	**100**	**4**
3	MTNT5314-18	Project Work (preliminary) (Students have to initiate the project work and at the end of the semester should present a progress seminar)	**D**	**-**	**-**	**20**	**250**	**10**
		TOTAL		**6**	**2**	**20**	**450**	**18**

OE: Open Elective; D: Dissertation

Electives

Elective-V		Open Elective	
MTNT5315-18	Nanotechnology in Food and Agriculture	MTNT5319-18	Business Analytics
MTNT5316-18	Nanotechnology in Health Care	MTNT5320-18	Industry Safety
MTNT5317-18	Biomaterials	MTNT5321-18	Operation research
MTNT5318-18	Quantum Computing	MTNT5322-18	Cost Management of Engineering Projects

Semester-IV

Sr.No.	Course Code	Course Name	Type of Course	Load Allocation			Total Marks	Credits
				L	T	P		
1	MTNT5411-18	Project Work (Students have to submit the final project report at the end of the semester which will be evaluated followed by a seminar presentation and viva – voce examination)	**D**	**-**	**-**	**32**	**400**	**16**
		TOTAL		**-**	**-**	**-**	**400**	**16**

D: Dissertation

Audit Course 1		
S.No.	**Course code**	**Name of the Course**
1	MTNT5124-18	English for Research paper writing
2	MTNT5125-18	Disaster Management
3	MTNT5126-18	Sanskrit for Technical Knowledge
4	MTNT5127-18	Value Education
Audit Course 2		
5	MTNT5225-18	Constitution of India
6	MTNT5226-18	Pedagogy studies
7	MTNT5227-18	Stress management of Yoga
8	MTNT5228-18	Personality Development through life enlightenment skills

Credit structure

S. No.	Type of Courses	Credits
1	Core courses	26
2	Elective Courses	24
3	Minor Project /preliminary project	12
4	Major Project	16
5	Total credits	78

Examination and Evaluation

S. No.		Weightage	Remarks
1.	Mid term/sessional Tests	24%	Best of two mid semester test will be considered for evaluation.
2	Attendance/Seminar	6%	
3	Assignments	10%	
4	End semester examination	60%	Conduct and checking of the answer sheets will at the Department level in case of University teaching Department or Autonomous institutions. For other colleges examination will be conducted at the university level.
5	Total	100%	Marks may be rounded off to nearest integer.
Practical			
1	Daily evaluation of practical record/Viva Voice/Attendance etc.	60%	Internal evaluation
2	Final Practical Performance + Viva Voice	40%	External evaluation
3	Total	100%	Marks may be rounded off to nearest integer.

Semester-I

MTNT5110-18	Quantum Mechanics	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Quantum Mechanics is to equip the M.Tech. students with the quantum techniques that he/she needs for developing basic understanding of matter at nanoscale and theoretical treatment required in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Understand the use of basic quantum concepts for describing nano systems and processes.
CO2	Understand and use the quantum methods for describing nano systems.
CO3	Understand theory of ensembles required for describing nano systems.
CO4	Understand advanced quantum techniques to describe the nano systems.
CO5	Use density functional theory quantum methods for describing quantum systems.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Introduction to Quantum Mechanics: Failure of Classical Mechanics; Brief discussion of general ideas such as dual nature of particles, Uncertainty principle, Superposition principle etc.; Solutions of Schrondinger Equation for 1-D and 3-D square wells and potential barriers, H-atom. Matrix Mechanics: Operators, Change of basis, eigen-values and Eigen-vectors; Simultaneous eigen vectors, Harmonic Oscillator in matrix mechanics; Exchange operators and identical particles. Angular Momentum: Introduction to angular momentum operators; Eigenvalues and Eigen vectors of L^2, Lz, Spin and J^2, Jz.

Unit-II

Approximation Methods: Non-Degenerate and degenerate perturbation theory and application to anharmonic oscillator, variational method with application to ground state of harmonic oscillator and hydrogen atom, General expression from the probability of transition from one state to another, constants and harmonic perturbation. Scattering Theory: Scattering Cross section and scattering amplitude, partial wave analysis, Bohr approximation and its application to potentials.

Unit III

Theory of Ensembles: The mocrocanonical Ensemble theory and its application to ideal gas of monoatomic particles; The canonical ensemble and its thermodynamics; Partition function; Energy fluctuations; Equipartition; A system of harmonic oscillators as canonical ensemble; The grand canonical ensemble and significance of statistical quantities.

Unit-IV

Density Functional Theory: Understand the role of DFT in modern chemistry, Electron correlation effect, pseudopotential, Hohenberg-Kohn Theorem, Degenerate Ground States, Variational Equation, Interacting v-Representability, Functional Differentiability, Effective Single-Particle Equations, Exchange-Correlation Energy Functional, Hellmann-Feynman Theorem, application of DFT for nano structures.

Books and Suggested Readings:

1. Quantum Mechanics: Theory and Applications– S. Lokanathan and A. Ghatak, Macmillan India Limited.
2. Quantum Mechanics – Leonard I. Schiff, Tata Mcgraw Hill.
3. Heat and Thermodynamics by M. W. Zymansky, R. H. Dittman, McGraw-Hill.
4. Statistical Physics by K. Huang, Wiley.
5. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004.
6. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
7. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
8. Quantum Physics: S. Gasiorowicz (Wiley, New York), 3rd ed. 2003.
9. Quantum Physics: Concepts and Applcations: Nouredine Zettili (Wiley, New York), 2009.

MTNT5111-18	Mathematical and statistical Methods at nanoscale	L-3, T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The main objective of this course is to provide the student with a repertoire of mathematical methods that are essential to the solution of advanced problems encountered in the field of nanoscience and technology. This course covers a broad spectrum of mathematical techniques including matrix theory, approximation of functions using polynomial interpolation, numerical differentiation and integration, numerical solution of differential equations and partial differential equations and simulation and Monte - Carlo methods

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

CO1	Understand the use of basic mathematical techniques for describing nano systems and processes.
CO2	Understand and use the numerical methods for describing nano systems.
CO3	Understand statistical methods required for describing nano systems.
CO4	Understand quantum statistics to solve the nano systems.
CO5	Use quantum statistical methods for describing quantum systems.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Solution of Linear Systems: Cramer's Rule - Gaussian elimination and Gauss Jordon methods - Cholesky decomposition method – Gauss Seidel iteration method – Eigenvalue problems : Power method with deflation for both symmetric and non symmetric matrices and Jacobi method for symmetric matrices.

UNIT II

Interpolation: Lagrange's interpolation - Newton's divided differences - Hermite's interpolation – Newton's forward and backward differences – Numerical differentiation – Numerical integration : Trapezoidal and Simpson's rules - Gaussian quadrature : 2 and 3 point rules.

UNIT III

Initial value problems for first and second order ODEs : Single step methods - Taylor's series method – Euler's and modified Euler's methods - Runge - Kutta method of fourth order - Multi step methods : Milne's and Adam Bashforth methods - Boundary value problems : Finite difference approximations to derivatives - Finite difference method of solving second order ODEs . Classification of second order PDE's - Finite difference approximations to partial derivatives -Elliptic equations : Solution of Laplace and Poisson equations.

UNIT VI

Random numbers: Random number algorithms and generators – Estimation of areas and volumes by Monte Carlo techniques - Numerical integration - Computing volumes – Simulation.

Unit-V

Quantum Statistical Methods: Quantum states and phase space, the density matrix, a few examples, An ideal gas in quantum mechanical ensembles; statistics of occupation numbers; Basic concepts and thermodynamic behavior of an ideal bose gas, Bose-Einstein Condensation.

Reference Books:

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2012.
2. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
3. Mathematical Physics: A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi),1986.
4. Mathematical Methods in the Physical Sciences – M.L. Boas (Wiley, New York) 3rd edition,2007.
5. Special Functions: E.D. Rainville (MacMillan, New York), 1960.
6. Mathematical Methods for Physics and Engineering: K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.

MTNT5116-18	Advanced Material Science	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Advanced Material Science** is to equip the M.Tech. students with the concepts required for understanding various properties of the materials which will be taught in this class and for developing a strong background if he/she chooses to pursue research in various domain of Nanoengineering as a career.

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

CO1	Understand basic elements of crystal structure of material
CO2	Understand accurate description of structure of crystalline solids
CO3	Understand type of binding in solids with focus on nanomaterials
CO4	Describe and understand basics of electronic properties of solids
CO5	Describe and understand behavior of defects in solids

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Crystal structure: Crystal systems, Crystal classes, Bravais lattice. Unit cell: Wigner-Seitz cell, equivalent positions in a unit cell. Notations of planes and directions. Atomic packing: packing fraction, Co-ordination number. Symmetry operations, point groups and space groups.

Unit-II

X-ray diffraction: Concept of reciprocal lattice, X-ray diffraction, Bragg law. Experimental diffraction methods: Rotating crystal method and Powder method.

Unit-III

Crystal binding: Types of binding, Van der Waals-London interaction, Repulsive interaction. Born's theory for lattice energy in ionic crystals, Ideas of metallic binding, Hydrogen Bonding

Unit-IV

Lattice vibrations: Vibrations of monoatomic lattices. First Brillouin zone. Quantization of lattice vibrations - Concept of Phonon, Phonon momentum. Specific heat of lattice (qualitative). Vibrations of monoatomic lattices. First Brillouin zone

Unit-V

Energy bands in solids: Formation of energy bands. Free electron model: free electrons in one and three dimensional potential wells, electrical conductivity, density of states, concept of Fermi energy. Semiconductors: Intrinsic and extrinsic semiconductors, concept of majority and minority carriers. Statistics of electrons and holes.

Unit- VI

Defects in solids: Point defects: Schottky and Frenkel defects and their equilibrium concentrations. Plane defects: grain boundary and stacking faults. Plane defects: grain boundary and stacking faults

Text and reference Books

1. Introduction to Solid State Physics, C. Kittel, Wiley Eastern.

2. A practical approach to X-Ray diffraction analysis by C.Suryanarayana.

3. Semiconductor Physics, P. S. Kireev, MIR Publishers.

4. Solid State Physics, A. J. Dekkar, Prentice Hall Inc.

5. Introduction to Superconductivity, M. Tinkham, McGraw-Hill, International Editions.

6. Elementary Solid State Physics: Principles and applications, M. A. Omar, Addison-Wesley.

MTNT5117-18	Elements of Physical Chemistry	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Elements of Physical Chemistry is to equip the M.Tech. students with the concepts of physical chemistry that he/she needs for understanding theoretical description of nanostructures to be taught in this class and for developing a strong background if he/she chooses to pursue research in Nanoscience and Engineering as a career.

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

CO1	Understand basic elements of nano material chemistry
CO2	Understand accurate description of Surface Chemistry
CO3	Understand type of Colloids with focus on nanomaterials
CO4	Describe and understand basics of Crystalline Structure of solids
CO5	Describe and understand Phase Transformations in nucleation

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Introduction: The scope of nano material chemistry, the nanoscale systems, Defining nano dimensional materials, Size effects in nano materials, Application and technology development, General methods available for the synthesis of nano dimensional materials. Atomic and Molecular Basics: Particles and Bonds, Chemical bonds in Nano technology, the shapes of molecules, additional aspects of bonding, molecular geometry: VSEPR Model, hybridization Van der Waals interactions, Dipole–Dipole Interactions, Ionic Interactions, Metal bonds, Covalent bonds, coordinative bonds, Hydrogen bridge bonds and polyvalent bonds.

Unit-II

Surface Chemistry: Adsorption and absorption, Adsorption isotherms, Freundlich adsorption isotherm, Langmuir adsorption isotherm, B.E.T. theory of multilayer adsorption, Gibbs adsorption isotherm, Application of adsorption.

Unit-III

Colloids: Classification of Colloids, Preparation of colloidal solutions, Purification of colloidal solution, Properties of colloidal solution, Emulsion, Gels, Uses of colloids, Micelle formation, The critical micellization concentration, Factors affecting the c.m.c.

Unit-IV

Crystalline Structure: Crystalline and amorphous solids, Isotropy and anisotropy, Crystal systems, Elements of symmetry, Space lattice and unit cell, Bravais lattice, Miller indices, imperfection in a crystal, points defects, line defects, Dislocations. Thermodynamics of surfaces: Introduction, Surface energy and its consequences, Thermodynamics of surfaces, The Gibbs adsorption equation, Thermodynamic behaviour of small particles, Homogenous nucleation.

Unit-V

Phase Transformations: Mechanisms of phase transformation; homogeneous and heterogeneous nucleation; spinodal decomposition; grain growth; precipitation in solid solution; transformation with constant composition; order-disorder transformations; Martensitic transformation.

Books and suggested reading:

1. Physical Chemitry by P. W. Attkins, Oxford Press.
2. Introduction to Modern Colloid Science by Robert J. Hunter, Oxford University Press.
3. Nanoscale Materials in Chemistry by Kenneth J. Khabhunde (ed.) Wiley Interscience.
4. Thermodynamics and Statistical Mechanics by A N Tikhonov, Peter Theodore Landsberg.
5. Thermodynamics and Statistical Mechanics by John M. Seddon, J. D. Gale.
6. Physical Chemistry, 1st Edition by David H. Ball, Brookes Cole.

MTNT5118-18	Processing and Properties of Nanostructured Materials	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Processing and Properties of Nanostructured Materials is to equip the M.Tech. students with the concepts of physical chemistry that he/she needs for understanding nanostructured materials in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	To learn basic material science with special, emphasize on nanomaterials
CO2	To know about processes in handling polymers and nanostructured materials
CO3	To understand various forms of nanomaterials and polymers for special applications
CO4	Understand Metal/Ceramic Powder synthesis methods for composite
CO5	Understand the environmental impact of nanostructured materials

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Classification of engineering materials - Tensile testing – Stress strain curve – Flow stress - Mechanical properties – Formability - Deformation processes - Mechanics of metal working – Metal forming - forging, rolling, extrusion, wire drawing – Superplastic forming – Bulk nanostructured materials by Severe Plastic Deformation (SPD) - Comparison of processes.

UNIT II

Defects in solids – classifications of defects – Microstructure – grain size, grain boundary, effects of processing and defects – Processing, microstructure, properties correlations – Mechanical Properties and processing - grain size evolution and grain size control; HallPetch relation- strengthening mechanisms; work hardening - grain boundary strengthening – solid solution strengthening – precipitation hardening - effects of diffusion on strength and flow of materials.

UNIT III

Engineering plastics – Pellets and sheets – Glass transition temperature of polymers – Melt flow index – Polymer processing tools and process conditions - injection moulding, thermoforming, vacuum and pressure assisted forming.

UNIT IV

Metal/Ceramic Powder synthesis - Selection and characterization of powders – compacting and sintering - Production of Porous and Dense Composite Components: Advanced composite materials - Metal- polymer- and ceramic- based composites and their properties – Fabrication of composite materials.

UNIT V

Properties of nanocrystalline materials required for structural, energy, environmental, textile and catalytic applications; processing techniques; techniques for retaining the nanocrystalline structure in service. Pervoskite structures, catalytic applications

Books and suggested reading:

1. A. Padmanabhan, “Mechanical Properties of Nanostructured Materials”, Materials Science and Engineering, A 304-306 (2001) 200-205.

2. C. Koch, “Nanostructured Materials: Processing, Properties and Applications”, 2nd Edition, Ed.: 2007

3. G. E. Dieter, adapted by D Bacon, “Mechanical Metallurgy”, SI Metric edition, McGraw Hill, Singapore, 1988.

4. H. Gleiter, “Nanocrystalline Materials”, Progress in Materials Science Vol. 33, pp. 223 -315, 1989

5. R. Asthana, A. Kumar and N. Dahotre “Materials Science in Manufacturing” Butterworth-Heinemann, Elsevier 2006.

MTNT5119-18	Solid State Physics	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Solid State Physics is to equip the M.Tech. students with the concepts of condensed phase of matter that he/she needs for understanding different courses taught in this class and for developing a strong background if he/she chooses to pursue academics or research in Nanoscience and Nanotechnology as a career.

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

CO1	Understand basic elements of crystal structure of condensed matter
CO2	Understand accurate description of lattice dynamics and thermal properties of crystalline solids
CO3	Understand origin of energy bands in solids with focus on semiconductors
CO4	Describe and understand basics of transport properties across solids
CO5	Describe and understand magnetic and dielectric behavior of solids

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Crystal binding and Elastic constants: Binding in solids; Cohesive energy, Crystals of Inert gases, ionic crystal, Covalent Crystals, Analysis of elastic strains: dilation, stress components; Elastic Compliance and Stiffness: elastic constants, elastic waves in cubic crystals.

Unit-II

Lattice Dynamics and Thermal Properties: Vibrations of crystal with monatomic and two atom per primitive Basis; Quantization of Elastic waves, Phonon momentum; Inelastic scattering by phonons, Phonon Heat Capacity, Planck Distribution, normal modes; Density of states, Debye T3 model; Einstein Model; anharmonic crystal interactions; thermal conductivity expansion.

Unit-III

Energy Band Theory: Electrons in a periodic potential: Bloch theorem, Nearly free electron model; Kronig Penney Model; Electron in a periodic potential; tight binding method; Wigner-Seitz Method Semiconductor Crystals, Band theory of pure and doped semiconductors; effective mass elementary idea of semiconductor superlattices.

Unit-IV

Transport Theory: Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance.

Unit-V

Dielectrics and Ferro Electrics: Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity; Dipole theory of ferroelectricity; thermodynamics of ferroelectric transition.

Text and Reference Books:

1. Introduction to Solid State Physics: *C. Kittel (Wiley, New York), 8th ed. 2005.*
2. Quantum Theory of Solids: *C. Kittel (Wiley, New York) 1987.*
3. Principles of the Theory of Solids: *J. Ziman (Cambridge University Press) 1972*
4. Solid State Theory: *Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.*
5. Liquid Crystals: *S. Chandrasekhar (Cambridge University), 2nd ed. 1992.*

MTNT5120-18	Optical Properties of Nanomaterials	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Optical Properties Of Nanomaterials is to equip the M.Tech. students with the concepts of optical properties of material at nanoscale that he/she needs for understanding different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanoscience & Nanotechnology as a career.

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

CO1	Understand basic properties of nanoparticles
CO2	Understand accurate description of optical properties of material at nanoscale
CO3	Understand basics of non-linear optics
CO4	Describe and understand basics of Plasmonics
CO5	understand application of nanomaterials with novel optical behavior

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT-I

Nanoparticles: Metal Nanoparticles, Alloy Nanoparticles, Stabilization in Sol, Glass, and other media, Change of bandgap, Blueshift, Colour change in sol, glass, and composites, Plasmon Resonance.

UNIT-II

Optical Properties: Optical luminescence and fluorescence from direct, bandgap semiconductor nanoparticles, surface trap passivation in core-shell nanoparticles, carrier injection, polymer-nanoparticle LED‘s and solar cells, electroluminescence; barriers to nanoparticle lasers; doping nanoparticles, Mn-ZnSe phosphors; light emission from indirect semiconductors, light emissionfrom Si nanodots.

UNIT-III

Non-linear Optics: Maxwell‘s Equations, Bloch‘s Theorem, Photonic Band Gap and Localized Defect States, Transmission Spectra, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab, 1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis, Applications of Nonlinear Photonic Crystals Devices, Materials: LiNbO3, Chalcogenide Glasses, etc, Wavelength Converters, etc

UNIT-V

Plasmonics: Introduction, merging photonics and electronics at nanoscale dimensions, single photon transistor using surface plasmon, nanowire surface plasmons-interaction with matter, single emitter as saturable mirror, photon correlation, and integrated systems. All optical modulation by plasmonic excitation of quantum dots, Channel plasmon-polariton guiding by subwavelength metal grooves, Near-field photonics: surface plasmon polaritons and localized surface plasmons, Slow guided surface plasmons at telecom frequencies.

Text and Reference Books:

1. Nanoplasmonics, From fundamentals to Applications vol 1 & 2- S. Kawata & H Masuhara 2006.
2. Nanotechnology for Microelectronics and Optoelectronics - J. M. Martinez-Duart,Raúl J.
3. Martín-Palma, Fernando Agullo-Rueda 2006
4. Springer Handbook of Nanotechnology by Bharat Bhushan 2004.
5. The Handbook of Photonics By Mool Chand Gupta, John Ballato 2007.

MTNT5121-18	Nano-electronics	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Nano Electronics is to equip the M.Tech. students with the concepts of nano scale electronic that he/she needs for understanding nano scale electronics for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Explain the nanoscale Semiconductor materials.
CO2	Discuss the basics of Plasmonic
CO3	Characterize the Principle and working of Spintronics
CO4	Describe the fabrication of Photonic crystals.
CO5	Understand current research areas in electronics at nanoscale

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Semiconductors: Tuning the band gap of nanoscale semiconductors, Quantum Confinement, Single Electron transistor, the colors and uses of quantum dots, Semiconductor nanowires- Fabrication strategies, quantum conductance effects in semiconductor nanowires, fabrication of porous Silicon. Fabrication of Nanobelts

Unit-II

Plasmonics: Introduction, single Emitter Properties, Ideal single photon transistor, Plasmonic Nano wires, Plasmonic Nano-lithography. Applications of Plasmonics

Unit-III

Spintronics: Introduction, Datta-Das Spin transistor, Johnoson Slisbee Spin Injection experiment, theory of spin injection through space charge region, spin relaxation in Bulk Semiconductors. Applications of Spintronic devices.

Unit-IV

Photonic crystals: Linear photonics crystals-Maxwell's equation, Bloch's theorem, transmission spectra, Nonlinear Photonic crystals, Fabrication of Photonic crystals (1-D and 2-D) applications of nonlinear photonic crystals devices

Unit-V

Solar energy devices: Solar cell basic working principles**,** basic principle of HOMO &LUMO, Bulk Heterojunction polymer solar cells, Dye Sensitized Solar cells**,** working of quantum dot solar cells. Applications of Solar energy devices

Unit-VI

Research topics: Electron Properties of Organic and Inorganic Light Emitting Diodes, Organic and inorganic Thin film Photovoltaics, Spintronics devices for memory and logic applications.

Text and referene Books:

1. Nanotechnology enabled sensors by Kouroush Kalantar – Zadeh, Benjamin Fry, Springer Verlag New York, (2007).
2. W. Ranier, Nano Electronics and Information Technology, Wiley, 2003.
3. K.E. Drexler, Nano systems, Wiley, (1992).
4. M.C. Gupta, J. Ballato, The Handbook of Photonics.

MTNT5122-18	Nanomaterials, Surface Interface and Catalysis	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Nanomaterials, Surface Interface and Catalysis** is to equip the M.Tech. students with the concepts related to the surface of nanomaterials that he/she needs for understanding different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanoscience & Nanotechnology as a career.

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

CO1	Describe the surface-interface concept and its properties especially surface energy and their states, and surface tension
CO2	Explain the binding of molecules to the surface, physio and chemio adsorptions and their kinetic models, thin films and their properties with epitaxial growth
CO3	Demonstrate the surface interface effects, and its characterization, coating surfaces with thin films.
CO4	Illustrate the surface segregation and self-assembly of block copolymer, non-lithographic patterning and micro contact printing.
CO5	Discuss the Nanostructure catalytic materials like Pt, Pd and Fe, colloidal and porous materials and applications.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Introduction: definitions, Surface energy and surface states, surface tension. Surface, Interface and Bulk- Surface - Surface electronic structure. Surface energy, surface tension

Unit-II

Surfaces and Interfaces: Binding of molecules to the surface, adsorption phenomenon chemisorption, and physorptions diffusion, nucleation. Adsorption isotherms, Ideal and real surface, surface states. Electron spectroscopy. Interaction of particles and radiation with surfaces, diffraction, secondary emission. Different properties of thin films and bulk, charge transport through thin films. Epitaxial growth. Different properties of thin and bulk films

Unit-III

Principles of Surface and Interface Chemistry: surface-interface energy and tension, wetting, characterization of surfaces and interfaces. Techniques for Manipulating Surfaces: adsorption of surfactants and macromolecules, physical grafting of macromolecules. physical grafting of macromolecules

Unit-IV

Structured Coatings: surface segregation and self-assembly in films of blends and copolymers, films by Langmuir-Blodgett. Non-Lithographic Patterning Methods: micro phase separation in copolymers, dewetting processes, microcontact printing, other uses of self assembly for pattern creation. other uses of self-assembly for pattern creation.

Unit-V

Nanostructure & Meosoporous materials & Applications: Nanostructured metals like Pt, Pd and Fe, nanostructured ceramics like silica, silcate and alumina, pillared clays, colloids and porous materials. Mesoporous- application with suitable examples, unipore size, bimodal pore size, supramolecular chemistry. colloids and porous materials.

Text and reference Books:

1. Handbook of Surface and Interface analysis, J.C. Riviere and S.Myhra, Marcell Decker Inc., 1998.
2. Nanstructured catalsysts- SL Scott, CM crudden and CW Jones.
3. Basic principles in applied catalysis-Mandfredlaerns.
4. Nanotechnology in catalysis- Pinzhan.
5. Chemistry of Nanomaterials, CNR Rao, A Muller and AK Cheetam.

MTNT5122-18	Synthesis and Characterization of Nanomaterials	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Synthesis and Characterization of Nanomaterials** is to equip the M.Tech. students with the concepts of synthesis and characterization required in nanoscience that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Understand the physical methods for synthesis of nanoparticles.
CO2	Understand the chemical methods for synthesis of nanoparticles.
CO3	Understand the biological methods for synthesis of nanoparticles.
CO4	Understand the various characterization techniques of nano materials
CO5	Understand various Lithographic Techniques for fabrication at nanoscale

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Physical Methods: Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and other variants, Electrodeposition.

Unit-II

Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, Post-synthetic size-selective processing. Solgel, Micelles and microemulsions, Cluster compounds.

Unit-III

Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis

Unit-IV

Characterization Techniques: X-ray diffraction, X-ray photoelectron and auger electron spectroscopy(XPS, AES), Scanning Probe Microscopy, SEM, TEM, Electron energy loss(EELS), Scanning tunneling microscopy(STM) and spectroscopy(STS), Atomic force microscopy(AFM), Magnetic force microscopy(MFM), Chemical Force Microscopy(CFM),Optical microscope and their description, operational principle and application for analysis of nanomaterials, UV-VIS-IR Spectrophotometers, Focused ion beam, nanolithography, Principle of operation and application for band gap measurements, Magnetic and electrical measurements and Infrared/ Raman, EPR and NMR.

Unit-V

Lithographic Techniques: AFM based nanolithography and nanomanipulation, E beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography.

Books and suggested readings:

1. Semiconductor Nanostructures and Nanodevices *Vol 1-5-A. A. Balandin, K. L.Wang*.
2. Springer Handbook of Nanotechnology: *Bharat Bhushan*
3. Nanofabrication towards biomedical application: Techniques, tools, Application and impact : *Ed. Challa S., S. R. Kumar, J. H. Carola.*

MTNT5112-18	Numerical Methods Lab	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Numerical Methods Lab** is to equip the M.Tech. students with the application of numerical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Apply basics knowledge of computational skills required for describing various physical systems.
CO2	Programme with the C++ or any other high-level language.
CO3	Use of various numerical methods in describing/solving physics problems.
CO4	Solve problem, critical thinking and analytical reasoning as applied to scientific problems.
CO5	Explore new areas of research in physics and allied fields of science and technology.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Programming using a suitable high level language (Matlab/Mathematica/Scilab/ Octave)

1. To find the standard deviation, mean, variance, moments etc. of at least 25 entries.
2. To choose a set of 10 values and find the least squared fitted curve.
3. Find y for a given x by fitting a set of values with the help of cubic spline fitting technique.
4. To find the Roots of an Algebraic Equation by Bisection method and secant method
5. To find the Roots of an Algebraic Equation by Newton-Raphson Method.
6. To find the Roots of Linear Equations by Gauss Elimination Method.
7. To find the Roots of Linear Equations by Gauss-Seidal Iterative Method.
8. Find first order derivative at given x for a set of values with the help of Lagrange interpolation.
9. To perform numerical integration of a function by Trapezoidal Rule.
10. To perform numerical integration of a function by Simpson's Rule.
11. To perform numerical integration of a function by Weddle's rule.
12. To solve a Differential Equation by Euler's method and Modified Euler's Method.
13. To solve a Differential Equation by Runge Kutta method.
14. To find the determinant of a matrix and its eigenvalues and eigenvectors.

Note: Students are expected to perform atleast 10-12 experiments from the list.

Text Books:

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.

Reference Books:

1. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

MTNT5113-18	Synthesis of Nanomaterial Lab	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Synthesis of Nanomaterial Lab is to equip the M.Tech. students with the application of various synthesis methods for nanomaterials required for understanding different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanoscience and Nanotechnology as a career.

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

CO1	Apply the physical methods for synthesis of nanoparticles.
CO2	Apply the chemical methods for synthesis of nanoparticles.
CO3	Apply the biological methods for synthesis of nanoparticles.
CO4	Understand the limitations of the synthesis techniques.
CO5	Understand various advancement in Techniques for synthesis at nanoscale.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

1. Ball milling route for making nanoparticles and particle size distribution estimation.
2. Physical vapor deposition and chemical vapor deposition techniques for thin film deposition.
3. Fabrication of suitable structures on thin films for device applications.
4. To synthesize metal nanostructures and investigate their optical behavior.
5. Synthesis and Characterization of carbon nanotubes by cracking of gas mixture
6. Bottom-up synthesis and characterization of PVP capped intrinsic & extrinsic ZnS QDs (using Na_2 SxH_2O as sulphur precursor).
7. Sol-gel synthesis and characterization of CdS nanocrystals.
8. Preparation and characterization of ZnO nanoparticles embedded in silica matrix
9. Microwave assisted synthesis of ZnO nanoparticles.
10. Eco-Friendly Bio-Chemical synthesis of nanomaterials.
11. To investigate refluxing and distillation techniques for synthesis of II-VI ceramic nanostructures.
12. To study solvothermal synthesis method of nanoparticles.

MTNT5114-18	Research Methodology and IPR	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Research Methodology and IPR is to equip the M.Tech. students with the application of numerical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Understand research problem formulation.
CO2	Analyze research related information
CO3	Follow research ethics
CO4	Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
CO5	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
CO6	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit I

Defining a research problem: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

Unit II

Literature review: Effective literature studies approaches, analysis Plagiarism, Research ethics.

Unit III

Effective technical writing: how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit IV

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit V

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit VI

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students".

Text and Reference books:

1. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
2. Ranjit Kumar, 2nd Edition,"Research Methodology: A Step by Step Guide for beginners"
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Mayall, "Industrial Design", McGraw Hill, 1992.
5. Niebel, "Product Design", McGraw Hill, 1974.
6. Asimov, "Introduction to Design", Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Semester-II

MTNT5210-18	Physics and Chemistry of Materials	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Physics and Chemistry of Materials** is to equip the M.Tech. students with the concepts of Physics and chemistry required for understanding the behavior of nanomaterials that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanoscience & Nanotechnology as a career.

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

CO1	Understand and describe Physical and chemical aspects of Nano materials
CO2	Understand and describe diffusion at nanoscale
CO3	Understand and describe surface defects in nanostructures
CO4	Understand and describe different classification of nanostructures
CO5	Understand and describe growth of Nano systems

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Physics Aspects: Size effect on thermal, electrical, electronic, mechanical, optical and magnetic properties of nanomaterials- surface area and aspect ratio- band gap energy- quantum confinement size effect.

UNIT II

Chemistry Aspects: Photochemistry and Electrochemistry of nanomaterials –Ionic properties of nanomaterials-Nano catalysis - Nanoscale heat transfer - Electron transport in transition metals and semiconducting nanostructures

UNIT III

Diffusion And Surface Defects: Fick's Law-mechanisms of diffusion - influence of pressure and temperature- Kirkendall effect -surface defects in nanomaterials - effect of microstructure on surface defects – interfacial energy.

UNIT IV

Nanostructures: Classifications of nanomaterials - Zero dimensional, one-dimensional and two dimensional nanostructures- Kinetics in nanostructured materials- multilayer thin films and superlattice clusters of metals, semiconductors and nanocomposites.

UNIT V

Nanosystems: Nanoparticles through homogeneous and heterogeneous nucleation-Growth controlled by surface and diffusion process- Oswald ripening process - influence of reducing agents- solid state phase segregation- Mechanisms of phase transformation- grain growth and sintering precipitation in solid solution- hume rothery rule

Text books and suggested readings:

1. A. S. Edelstein and R. C. Cammarata, “Nanomaterials: Synthesis, Properties and Applications”, Institute of Physics Pub., 1998.

2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications , Imperial College Press, 2004.

3. G.A. Ozin and A.C. Arsenault, “Nanochemistry : A chemical approach to nanomaterials”, Royal Society of Chemistry, 2005.

4. Joel I. Gersten, “The Physics and Chemistry of Materials”, Wiley, 2001.

5. K.W. Kolasinski, “Surface Science: Foundations of Catalysis and Nanoscience”, Wiley, 2002.

6. Physical Chemistry – Atkins Peter, Paula Julio.

MTNT5211-18	Nano biotechnology	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Nano biotechnology** is to equip the M.Tech. students with the concepts of biotechnology required for understanding the behavior of nano biomaterials that he/she needs for for developing a strong background if he/she chooses to pursue research in Nanoscience & Nanotechnology as a career

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

CO1	Understand the basics of Biotechnology
CO2	Explain the interaction between biomolecules and nanoparticle surface and its applications.
CO3	Optimize the synthesis of Biocompatibility of Nanomaterials
CO4	Analyze different types of DNA based Nanostructures
CO5	Identify the risk assessments involved bio nano materials

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit –I

Introduction to the science of nano as nanobiotechnology
Development of nanobiotechnology - timelines and progress, overview.
Basics of biology - cell, organelles and nucleic acids as genetic material.
Bio macromolecules - Carbohydrates, lipids, proteins and Nucleic acids.

Unit –II

Nanomaterial in biotechnology - nanoparticles, quantum dots, nanotubes and nanowires.
Biosensors ; different classes -molecular recognition elements, transducing elements.

Unit –III

Applications of molecular recognition elements in nanosensing of different analytes.
Application of various transducing elements as part of nanobiosensors.
Miniaturized devices in nanobiotechnology - types and applications, lab on a chip concept.
Cell as Nanobio-machine, link between the signalling pathways & molecular movements as well as neuron function

Unit –IV

Biological nanoparticles production - plants and microbial.
Nanobiotechnological applications in health and disease - infectious and chronic.
Nanobiotechnological applications in Environment and food - detection and mitigation

References:

1. Jain K.K, Nanobiotechnology in Molecular Diagnostics – Current Techniques andApplications, Taylor and Francis Publications 2006.
2. Nanobiotechnology: Concepts,Applications and Perspectives (2004), Christof M.Niemeyer (Editor), Chad A. Mirkin (Editor), Wiley VCH.
3. Nanobiotechnology - II more concepts and applications. (2007) - Chad A Mirkin and Christof M. Niemeyer (Eds), Wiley VCH.
4. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications.

MTNT5217-18	Carbon Nanostructures and Applications	L-3 ,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Carbon Nanostructures and Applications is to equip the M.Tech. students with the various carbon nanostructures that he/she needs for developing a strong background if he/she chooses to pursue research in application of nanostructures.

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

CO1	Explain the different nanostructures like whiskers, cones and polyhedral crystalsand their structure properties and application
CO2	Describe the type of carbon nanotubes and different synthesis methods and growth mechanisms.
CO3	Demonstrate the graphite derivatives, fullerenes and its type, nano-diamond, graphene, different synthesis methods and their functionalization and applications
CO4	Identify the application of carbon nanostructure for different day-to-day applications.
CO5	Differentiate the nanostructure catalytic materials like Pt, Pd and Fe, colloidal and porous materials.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Nanostructures: Graphite, Whiskers, Cones, and Polyhedral crystals, structure, Properties and applications. Graphite.

Unit-II

Carbon Nanotubes (CNT): History, types of CNTs, synthesis methods, CVD method, Laser ablation and electric arc processes, growth mechanisms, purification and characterization methods, solid disordered carbon nanostructures. purification and characterization methods.

Unit-III

Properties and applications of CNTs: electrical, vibrational, mechanical, optical properties and Raman spectroscopy of CNTS, carbon cluseters, decoration of CNT by nano metals and metal oxides, Applications-Lithium ion battery, fuel cells, sensor applications, applications to nanoelectronics, nanocomposites. decoration of CNT by nano metals and metal oxides.

Unit-VI

Graphite derivatives: Fullerenes and types, nano-diamond, clusters, metal carbide derived carbon nanostructures, synthesis and applications. Graphene: - Background, structure, exfoliation or synthesis methods- physical and methods – micromechanical (scotch t ap emethod), CVD, Chemical approaches -Hammers method, oxidation and reduction of graphite, solvo-thermal synthesis.

Unit-5

Functionalization of carbon nanostructures: (CNT, Graphene and fullerenes)- reactivity, covalent functionalization-oxidative purification, defect functionalization, transformation and modification of carboxylic functionalization like thiolation, halogenations,hydrogenation, sidewall functionalization through electorphilic addition, non-covavlent exohedral functionalization, endohedro functionalization. exohedral functionalization, endohedro functionalization.

Unit-6

Carbon nanostructure applications: Lithium ion battery, fuel cells, hydrogen storage, sensor applications, applications to nano-electronics, nano-composites, nano wires in drug delivery, polymer reinforcement and as filler materials.

References:

1. Science of Fullerenes and Carbon Nanotubes by M.S. Dresselhaus, G. Dresselhaus and P.C. Eklund, Science Direct 1996.

MTNT5218-18	Nanostructured Materials for Clean Energy	L-3,T-1,P-0	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Nanostructured Materials for Clean Energy is to equip the M.Tech. students with the concepts of energy domains that he/she needs for understanding potential of nanotechnology for addressing energy problem and for developing a strong background if he/she chooses to pursue research in Nanoscience & Nanotechnology as a career.

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

CO1	Understand the basic and essential elements of battery materials
CO2	Explain the mechanism of harnessing solar energy.
CO3	Discuss the fabrication of solar cell structures.
CO4	Define and design how hydrogen energy can be stored
CO5	Analyse the safety and precautionary issues in handling nanomaterials.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit -I

Battery materials and batteries: Lithium Ion based batteries. Types of batteries

Unit -II

Renewable energy Technology: Energy challenges, nanomaterials and nanostructures in energy harvesting, developments and implementation of nanotechnology based renewable energy technologies. Nanostructures in energy harvesting

Unit -III

Solar cell structures: quantum well and quantum dot solar cells, photo- thermal cells for solar energy harvesting, Thin film solar cells, CIGS solar cells, Dye sensitized solar cells. Dye sensitized solar cells.

Unit –IV

Hydrogen storage Technology: Hydrogen production methods, purification, hydrogen storage methods. Hydrogen storage materials: metal hydrides, Complex metal hydrides and metal-organic framework materials, volumetric and gravimetric storage capacities, hydriding and dehydriding kinetics, high enthalphy formations and thermal management during hydriding reaction, multiple catalytic – degradation of sorption properties, automotive applications. Gravimetric storage capacities.

Unit –V

Fuel cell Technology: Fuel cell Principles, types of fuel cells (Alkaline Electrolyte, Phosphoric acid, Molten Carbonate, solid oxide and direct methanol and Proton exchange fuel cells), Principle and operation of Proton Exchange Membrane (PEM) fuel cell.

Unit – VI

Environmental and Safety issues: Nanoparticles and environment - Nanoparticles in atmospheric environment, Indoor environments Industrial processes and nanoparticles ; Safety of nanoparticles-Problems caused by nanoparticles.

Text & References books:

1. Renewable Energy Resources by J. Twidell and T.Weir, E&FN Spon Ltd.

2. Hydrogen from Renewable Energy Source by D.Infield

3. Fundamentals of Industrial Catalytic Process by C.H. Bartholomew and Robert J. Farraoto,

John Wiley & Sons Inc.

4. Fuel storage on Board Hydrogen storage in Carbon Nanostructures by R.A. Shatwell

MTNT5219-18	Nanotoxicology	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Nanotoxicology** is to equip the M.Tech. students with the concepts of toxicology associated with various nanostructures and nanomaterials that he/she needs for for developing a strong background if he/she chooses to pursue research in nanoscience & Nanotechnology as a career.

Course Outcomes: At the end of the course, the student will be

CO1	To make students learn various concepts of toxicity, and its effects
CO2	To make students learn various concepts about protocols in toxicology studies
CO3	To help them gain knowledge about the toxicity in Nanoscience, and their effects on Human.
CO4	To enhance knowledge on the risk management of nanoparticle exposure
CO5	To enhance knowledge on the nanotoxicology - prevention and remedies

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Introduction to Toxicology: Concept of Toxicology-Types of toxicity based on route of entry, nature of the toxin. Toxicodynamics–Dose vs Toxicity Relationships. Toxicokinetics – ADME, LADMET hypothesis. Genotoxicity and carcinogenicity – Mechanisms and Tests. Organ toxicity – Respiratory**,** dermal, hepato, neuro and nephro.

UNIT II

Nanotoxicology: Characteristics of Nanoparticles that determine Potential Toxicity. Bio-distribution of nanoparticles. Interaction of Nanoparticles with Biomembrane and genes. Evaluation of Nanoparticle transfer using placental models. Nanomaterial toxicity – Pulmonary**,** dermal, hepato, neuro, ocular and nephro; Estimation of Nanoparticle Dose in Humans. In vitro toxicity studies of ultrafine diesel exhaust particles; Toxicity studies of carbon Nanotubes

UNIT III

Protocols in Toxicology Studies: Methods for toxicity assessment – Cyto, Geno, hepato, neuro, nephrotoxicity. Assessment of toxicokinetics. Assessment of oxidative stress and antioxidant status.

UNIT IV

Animal Models: Types, species and strains of animals used in toxicity studies. Dosing profile for animal models. Studies on toxicology, pathology and metabolism in mouse and rat. Laws and Regulations Governing Animal Care and Use in Research.

UNIT V

Risk Assessment and Execution: Risk assessment of Nanoparticle exposure. Prevention and control of nanoparticles exposure. Regulation and recommendations

REFERENCES:

1. A Reference handbook of nanotoxicology by M.Zafar Nyamadzi 2008.

2. Andreas Luch, 'Molecular, Clinical and Environmental Toxicology Volume 2: Clinical

Toxicology', BirkhauserVerlag AG 2010.

3. John H. Duffus, Howard G. J. Worth, 'Fundamental Toxicology', The Royal Society of

Chemistry 2006.

4. Lucio G. Costa, Ernest Hodgson, David A. Lawrence, Donald J. Reed,William F. Greenlee,

'Current Protocols in Toxicology', John Wiley & Sons, Inc. 2005.

MTNT5220-18	Imaging Techniques for Nanotechnology	L-3,T-1, P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Imaging Techniques for Nanotechnology** is to equip the M.Tech. students with the concepts of imaging techniques that he/she needs for understanding nanostructures, their limitations and skills required for developing a strong background in experimental methods, if he/she chooses to pursue research in Nanoscience & Nanotechnology as a career.

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

CO1	To learn noninvasive microscopic techniques such as optical and electron microscopy
CO2	To learn invasive microscopic techniques such as atomic microscopy.
CO3	To learn invasive scanning electron microscopy.
CO4	To learn invasive transmission electron microscopy.
CO5	To understand advancement in various microscopic techniques.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Optical Microscopy: Optical microscopy- Use of polarized light microscopy – Phase contrast microcopy – Interference Microscopy – hot stage microscopy - surface morphology – confocal microscopy.

UNIT II

Scanning Electron Microscopy: Basic design of the scanning electron microscopy – Modes of operation– Backscattered electrons – secondary electrons- X-rays – typical forms of contrast– Resolution and contrast – enhancement – Specimen Preparation, Replicas Various-application of SEM.

UNIT III

Transmission Electron Microscopy: Basic principles - Modes of operation – Specimen preparation – Diffraction in imperfect crystals – Dislocations – precipitates – Structure of Grain boundaries and interfaces- HRTEM use in nanostructures.

UNIT IV

Atomic Force Microscopy: Basic concepts-Interaction force-AFM and the optical lever- Scale drawing- AFM tip on nanometer scale structures- force curves, measurements and manipulations-feed back control different modes of operation –contact, non contact and tapping mode-Imaging and manipulation of samples in air or liquid environments-Imaging soft samples. Scanning Force Microscopy-Shear force Microscopy-Lateral Force Microscopy-Magnetic Force microscopy.

UNIT V

Scanning Tunneling Microscopy: Principle- Instrumentation- importance of STM for nanostructures – surface and molecular manipulation using STM -3D map of electronic structure

Text and reference books:

1. J.Goldstein, D.E.Newbury, D.C.Joy, and C.E.Lym, " Scanning Electron Microscopy and

X-Ray Microanalysis", 2003.

2. P.J. Good hew, J.Humphreys, R.Beanland, "Electron Microscopy and Analysis, 2001.

3. R.Haynes, D.P.Woodruff and T.A.Talchar, " Opitcal Microscopy of Materials", Cambridge University Press, 1986.

4. S.L. Flegler, J.W. Heckman and K.L.Klomparens, " Scanning and Transmission Electron

Microscopy: An Introduction", W.H.Freeman & Co, 1993.

MTNT5221-18	Cellular Biochemistry	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Cellular Biochemistry is to equip the M.Tech. students with the concepts of biology and chemistry that he/she needs for understanding of cellular bio components in nano-biotechnology or health care and for developing a strong background if he/she chooses to pursue research in Nanoscience and Nanotechnology as a career.

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

CO1	To acquire basic knowledge on cell biology
CO2	To acquire basic knowledge on nucleic acids, amino acids
CO3	To acquire knowledge on carbohydrates, lipids and proteins.
CO4	To acquire knowledge on Enzymes
CO5	To know about their metabolisms and energy production.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Cell Biology: Eukaryotic and Prokaryotic cells-Structure and functions, Principle of membrane organization. Cytoskeletal proteins, Types of cell division- mitosis and meiosis, Cell cycle and and its regulation. Screening of microbes using nanofluidic chips.

UNIT II

Nucleic Acids: Genome structure and organization in prokaryotes and eukaryotes. Structure and function of nucleic acids. Replication, transcription and translation- mechanism, enzymology and regulation. Central Dogma of life. Two case studies on DNA nanotechnology.

UNIT III

Amino Acids and Proteins: Structure and properties of amino acids. Peptide bond. Proteins-Classification and functions of proteins. Primary, secondary, super secondary, tertiary, quaternary structures and bonding interactions. Enzymes- properties, structure, assay and inhibition. Synzymes, ribozymes.

UNIT IV

Carbohydrates and Lipids: Classification, Nomenclature, Structure, Function of carbohydrates and lipids. Membrane transport.

UNIT V

Metabolism and Energy Production: Integrative Metabolism of biomolecules, Electron transport chain, oxidative phosphorylation, energy production.

Text and reference books:

1. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.
2. B.Lewin, “Genes IX”, International Edition. Sudbury: Jones & Bartlett, 2007.
3. Branden, Carl-Ivar, and John Tooze. Introduction to Protein Structure. 2nd ed. New York: Garland Pub., 1991.
4. Creighton, E, Thomas, “Proteins: Structures and Molecular Properties”, 2nd Ed. New York:
5. R. Cantor, P.R.Samuel, “Biophysical Chemistry”, W.H., Freeman & Co., 1985.
6. Watson, James, T.Baker, S.Bell, A.Gann, M.Levine, and R.Losick. “Molecular Biology of the Gene”, 5th ed., San Francisco: Addison-Wesley, 2000.

MTNT5222-18	Bio safety and Hazards of Nano Materials	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Bio safety And Hazards of Nano Materials** is to equip the M.Tech. students with the concepts of bio safety, bioethics and patenting that he/she needs for for developing a strong background if he/she chooses to pursue research in Nanoscience and Nanotechnology as a career.

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

CO1	Identify different types of nano materials and its applications
CO2	Explain problems and issues of Bio nano materials
CO3	Understand the patent of research article
CO4	Define the safety and handling of nano materials
CO5	Describe the toxic and hazards of Nanomaterials

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Introduction: Properties of nanomaterials, Interactions between biomolecules and nanoparticles surface, different types of materials used for the synthesis of hybrid nano-bio assemblies, applications of nano in biology, nanoprobes for clinical biotechnology. Nanomaterials and their applications in agriculture, environment and medicine.

Unit-II

Bioethics: Introduction to Bioethics. Social and ethical issues in Biotechnology. Definition of Biosafety. Biosafety for human health and environment. Social and ethical issues. Use of genetically modified organisms and their release in to the environment.

Unit-III

Patenting: Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation, International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India

Unit-IV

Biosafety: Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol. Identification of nano specific risks – responding to challenge Risk assessment related to nanotechnology-environmental.

Unit-V

Nanotoxicology: Inhalation of nano materials–overview. Introduction Inhalation – deposition and pulmonary clearance of insoluble solids- bio–persistence of Inhaled solid material. Systemic translocation of inhaled particles .pulmonary effects of SWCNT–pulmonary inflammatory Reponses to SWCNT. *In vivo* – interaction of the pulmonary inflammation with oxidative stress–interactions of SWCNTs with macro phages. hazard characterization, exposure assessment and risk calculation.

Text and refercence books:

1.J. B Park, "Biomaterials Science and Engineering", Plenum Press, New York, 1984.

2.P.P. Simeonova, N. Opopol and M.I. Lus ter, "Nanotechnology - Toxicological Issues and Environmental Safety", Springer 2006.

3.Vinod Labhasetwar and Diandra L. Leslie, "Biomedical Applications of nanotechnology", A John Wiley & son Inc, N.J, USA, 2007.

MTNT5223-18	Advanced Drug Delivery Systems	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Advanced Drug Delivery Systems** is to equip the M.Tech. students with the concepts of biology required for development of target drug delivery that he/she needs for developing a strong background if he/she chooses to pursue research in Nanoscience and Nanotechnology as a career.

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

CO1	To learn about Fundamentals of drug delivery systems
CO2	To study the Lipid Based Nanocarriers
CO3	To study the Microbes and Antibody Based Nanocarriers
CO4	To study the materials and techniques used in Delivery systems
CO5	To learn about Recent development in the area of devices and therapy.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Theory of Advanced Drug Delivery: Routes of drug delivery, Fundamentals of Nanocarriers - Size, Surface, Magnetic and Optical Properties, Pharmacokinetics and Pharmacodynamics of Nano drug carriers. Critical Factors in drug delivery. Transport of Nanoparticles - In Vitro and Ex Vivo Models.

UNIT II

Polymers: Dendrimers-Synthesis-Nanoscale containers- Dendritic Nanoscafold systems-Biocompatibility of Dendrimers, Gene transfection. pH based targeted delivery- chitosan and alginate. Copolymers in targeted drug delivery- PCL,PLA, PLGA.

UNIT III

Lipid Based Nanocarriers: Liposomes, niosomes and solid lipid nanoparticles. Ligand based delivery by liposomes. Cubosomes.

UNIT IV

Microbes and Antibody Based Nanocarriers: Bacterial dependent delivery of vaccines. Drug delivery and subcellular targeting by virus, Drug packaging and drug loading. Delivery of therapeutics by antibodies and antibodybioconjugates.

UNIT V

Devices For Drug Delivery: Fabrication and Applications of Microneedles, Micropumps, microvalves. Implantable microchips.

Text and reference books:

1. Drug Delivery and Targeting, A.M. Hillery, CRC Press, 2002.

2. Drug Delivery: Engineering Principles for Drug Therapy, M. Salzman, Oxford University Press, 2001.

3. Drug Delivery: Principles and Applications, B. Wang, Wiley Intersceince, 2005.

4. Nanoparticle Technology for Drug Delivery, Ram B. Gupta, Uday B. Kompella Taylor & Francis, 2006.

MTNT5224-18	Structures, Spectra and Properties of Biomolecules	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The aim and objective of the course on **Structures, Spectra and properties of Biomolecules** is to familiarize the M.Tech. students with the basics of the recently emerging research field of dynamics of Structures, Spectra and properties of Biomolecules.

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

CO1	Describe various structural and chemical bonding aspects of Biomolecules.
CO2	Understand structure and ttheoretical techniques and their application to Biomolecules.
CO3	Understand use of various spectroscopic techniques and their application to the Biomolecules.
CO4	Understand the structure-Function relationship and modeling of biomolecules.
CO5	Outline and correlate for providing solution to interdisciplinary problem

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Structure Aspects of Biomolecule: Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides.

Unit-II

Theoretical Techniques and Their Application to Biomolecules: Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses.

Unit-III

Spectroscopic Techniques and their Application to Biomolecules: Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids.

Unit-IV

Structure-Function Relationship and Modeling: Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model.

Text and reference books:

1. Srinivasan & Pattabhi: Structure Aspects of Biomolecules.
2. Govil & Hosur: Conformations of Biological Molecules
3. Price: Basic Molecular Biology
4. Pullman: Quantum Mechanics of Molecular Conformations
5. Lehninger: Biochemistry
6. Mehler&Cordes: Biological Chemistry
6. Smith and Hanawait: molecular Photobiology, Inactivation and Recovery

MTNT5212-18	Characterization of Nanomaterials Lab	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Characterization of Nanomaterials Lab** is to equip the M.Tech. students with the application of characterization techniques that he/she needs for studying properties of nanomaterials required in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Apply the X-ray diffraction (XRD) of nanomaterials.
CO2	Apply the EM based experimental data of nanoparticles.
CO3	Apply the Spectroscopic characterization of nanoparticles.
CO4	Understand the limitations of the characterization techniques.
CO5	Understand various UV-Vis. Absorption spectroscopy of nanomaterials.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

1. X-ray diffraction (XRD): Phase analysis of binary mixture; indexing of XRD peaks and lattice structure refinement.
2. Selective area electron diffraction: Software based structural analysis based on TEM based experimental data from published literature. (Note: Later experiment may be performed in the lab based on availability of TEM facility).
3. SEM: Comparative microstructural analysis using FESEM on (i) cleaved HOPG, (ii) cleaved Mica, (iii) Glass, (iv) Si and (v) oxide sample (e.g., BaTiO3).
4. EDXA (SEM based): EDXA of a multicomponent sample.
5. Complex impedance spectroscopy for electronic property evaluation (e.g., on BaTiO3).
6. Surface area and pore volume measurements of nanoparticles (a standard sample and a new sample, if available).
7. To investigate the optical properties of certain nanosized semiconducting oxides.
8. To study the size quantization effects in semiconducting nanosystems using optical and emission tools.
9. Spectroscopic characterization of metallic, semiconducting and insulating nanoparticles.
10. Particle size and lifetime analysis using dynamic light scattering.
11. To analyze the thickness, Optical transmission and reflectivity of thin film of Al.
12. To work out the charge, Zeta potential and xize distribution of colloidal solution of nanoparticle using dynamic light scattering method.
13. To determine the elemental contents in nanoalloys using different analytical techniques.
14. To investigate photo-catalytic activity of nanomaterials.
15. To study the Band Gap of Nano crystals using UV-Vis. Absorption spectroscopy.

MTNT5213-18	Material Simulation Lab	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Synthesis of Nanomaterial Lab is to equip the M.Tech. students with the application of numerical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Apply basics knowledge of computational skills required for describing various physical systems.
CO2	Programme with the C++ or any other high level language.
CO3	Use of various numerical methods in describing/solving Physics problems.
CO4	Solve problem, critical thinking and analytical reasoning as applied to scientific problems.
CO5	Explore new areas of research in physics and allied fields of science and technology.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

1. Simulation of Ising Model using Metropolis Algorithms.
2. Simulation of Potts Model and its application in studying magnetic properties.
3. *Ab Initio* Quantum mechanical simulation of of electrical, optical and structural properties.
4. Force field Method simulation of thermodynamic, Kinetic and electrical properties.

MTNT5214-18	Mini Project	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Mini Project is to equip the M.Tech. students with the exposure to various domains of planning and writing about the research project that he/she needs for for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	design and carry out scientific experiments as well as accurately record and analyze the results of experiments/theory.
CO2	skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
CO3	clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.
CO4	explore new areas of research in physics and allied fields of science and technology.
CO5	appreciate the central role of physics in our society and use this as a basis for ethical behavior

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Minor Project on Current Trends in Nanotechnology covering Synthesis Process, Fabrication and Characterization of nanomaterials and their applications in devices.

Note: Minor Project work is to be carried out and submitted within the stipulated time in consultation with the concerned guide of the candidate.

Semester-III

MTNT5315-18	Nanotechnology in Food and Agriculture	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Nanotechnology in Food and Agriculture** is to equip the M.Tech. students with the concepts of nanotechnology required in the field of food and agriculture that he/she needs for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Define intermolecular as well as hydrophilic and hydrophobic interactions, soluble polymers, self assembly in plant cells.
CO2	Introduce the nanotechnology in food, food production, antimicrobial functionality, functional materials in food nanotechnology.
CO3	Explain the nanotechnology in Agricultural field, different Enzyme and DNA based biosensors, RFIDs tag, Nano-sensors networks.
CO4	Define advanced processing techniques for food processing like infrared processing, dielectric heating, microwave processing, and self-life analysis of food characteristics.
CO5	Elucidate food quality, safety and security of agricultural product, packaging and distribution, nanomaterials for food applications.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Intermolecular Interactions: Introduction, Hydrophobic and Hydrophilic Interactions, Dispersion Interaction, Electrostatic Interactions, Steric Interactions Involving Soluble Polymers. Self-Assembly, Plant Cells, Organized Self-Assembled Structures.

Unit-II

Nanotechnology in Food: Introduction, Food Production, Antimicrobial Functionality, Visual Indicators, Physics and Structures in Food Bionanotechnology, Information and Communication Technology, Fibrillar Structures, Plate-Like Structures, Spherically Symmetric Structures, Bi-continuous Structures in Protein–Polysaccharide Systems, Gastronomy and the Nanodomain: Molecular Gastronomy, functional materials in food nanotechnology.

Unit-III

Nanotechnology in Agricultural: Introduction, Biosensors, Enzyme Biosensors and Diagnostics, DNA-Based Biosensors and Diagnostics, Radiofrequency Identification (RFID), Integrated Nanosensor Networks: Detection and Response, Precision Agriculture, Potential Changes in Farming Methods and Sustainable Agriculture.

Unit-IV

Advanced Processing Technologies: Introduction, Preservation Methods, Drying Techniques, Conventional methods and its limitation, Infrared processing, di-electric heating, microwave processing, batch type and conveyor type systems, shelf-life, analysis of food characteristics.

Unit-V

Food Quality, Safety, and Security: Introduction, Improving Quality, Safety, and Security of Agricultural Production, Food Processing, Packaging and Distribution. Concerns about using Nanotechnology in Food Production. Reasons to Package Food Products, Physical Properties of Packaging Materials. Safety Assessment of Oral-Exposure Engineered Nanomaterials for Food Application. Toxicity aspects of nanofood, modification of nano materials to avoid toxic effect and commercial aspect.

Text Books:

1. Lynn J. Frewer, Willem Norde, Arnout Fischer, Frans Kampers "Nanotechnology in the Agri-Food Sector" John Wiley and Sons, 2010.

2. S.Choudhary, 'Applied Nanotechnology in Agriculture', Arise Publication, 2011.

MTNT5316-18	Nanotechnology in Health Care	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The main objective of this course is to provide the student with Nanotechnology in Health Care that are essential to the solution of advanced problems encountered in the field of nanoscience and technology

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

CO1	To be introduced to recent advancements in nano medicine.
CO2	learn developments in nanostructured materials used for medical implants
CO3	learn about nano diagnostics.
CO4	Learn harmful effects of nanoparticles
CO5	understand need of nanotechnology in health care

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Trends In Nanobiotechnology: Nanotechnology in gene therapy. Stem Cell technology. PCR, ELISA, DNA Profiling and Blotting techniques-Nanoprobes.

UNIT II

Nanoimmuno Technology: Nanoimmunoassay and nano-immunosensors- Bio-Barcode Assay- use of magnets, gold, DNA and antibodies. Immunodiagnostics for cancer and central nervous system disorders.

UNIT III

Nanotechnology Based Medical Diagnostics: Improved diagnosis by i*n vivo* imaging - detection of tumors, plaque and genetic defects. Nanobot medical devices. Cantilever Sensors.

UNIT IV

Prosthetic and Medical Implants: Prosthesis and implants. neural, ocular, cochlear, dental implants. implants and prosthesis of skin, limb, bone. Artficial organ and Organ transplant. Nanofibre scaffold technology.

UNIT V

Biomedical Applications Of Nanotechnology: Nano-bioconjugates and their significance. Nanoscaffolds. Magnetic Nanoparticles. Multifunctional Inorganic and organic nanoparticles and their biomedical applications

Text and Reference books:

1. Biosensors and modern biospecific analytical techniques, Wilson & Wilson's.
2. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester; 2002.
3. Comprehensive Analytical Chemistry; Ed. L Gorton; Elsevier, Amsterdam.
4. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester : 2nd ed.; 2001. London; 2005.

MTNT5317-18	Biomaterials	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course is to know the classification of biomaterial, their bulk and surface properties and characterization to prepare the students to find a place in biomedical field.To learn the various biological responses to the materials and biomechanics .To have an exposure on the clinical context of their use, manufacturing processes and testing, cost, sterilization, packaging and regulatory issues.

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

CO1	Learn about the basic understanding and classification of nano biomaterial
CO2	Understand the Bulk and surface characterization
CO3	Understand the methods for Testing biocompatibility
CO4	Learn about Tissue replacement implants with biomaterials
CO5	Learn about the Artificial organs with biomaterials

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

UNIT I

Introduction and Classification: Introduction and classifications; Metals: different types, properties and interaction with the tissue, Polymers: classification and properties, Ceramics: Types, properties and interactions with the tissue, Composites: matrix and reinforcing agents/fillers and properties, Cell adhesion, host- tissue reactions. Tissue derived biomaterials: Structure and properties of collagen and collagen-rich tissues, Biotechnology of collagen, design of resorbable collagen-based medical implants soft.

UNIT II

Bulk and Surface Characterization: Bulk Characterization: XRD, FT-IR, SEM, energy dispersive X-ray (EDX), DSC, TGA, dielectric analysis (DEA); Surface analysis: XPS, SIMS, AES, surface enhances Raman spectroscopy (SERS), AFM/STM; Structural properties of tissues-bone, teeth and elastic tissues, Effects of sterilization on material properties.

UNIT III

Testing Biocompatibility: blood and tissue compatibility; degradation of biomaterials in biological environment, toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests; In vitro and In vivo testing, implant associated infections, biocompatibility enhancement using carona discharge and plasma processes, surface coatings; Ethical considerations, good manufacturing practice, standards, Regulatory issues.

UNIT IV

Tissue Replacement Implants with Biomaterials: Tissue replacements, sutures, surgical tapes, adhesive, percutaneous and skin implants, maxillofacial augmentation, blood interfacing implants, hard tissue replacement implants, internal fracture fixation devices, Joint replacements.

UNIT V

Artificial Organs with Biomaterials: Artificial heart, prosthetic cardiac valves, limb prosthesis, externally powered limb prosthesis, Dental implants.

Text and reference books:

1. D. Shi , Ed., “Biomaterials and Tissue Engineering”, Berlin, New York: Springer, 2004.

2. Joon Park, D.B. Joseph , “Biomaterials: Principles and Applications”, CRC, Press, 2003.

3. Kay C. Dee, David A. Puleo and Rena Bizios, “An Introduction to Tissue-Biomaterial Interactions”, John wiley, 2002.

4. L. Hench and J. Jones, “Biomaterials, Artificial Organs and Tissue Engineering”,

Woodhead Publishing in Materials, 2002.

MTNT5318-18	Quantum Computing	L-0,T-0,P-4	2 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Quantum Computing** is to equip the M.Tech. students with the concepts of quantum information that he/she needs for for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	Gain facility of some of the many concepts and techniques in second generation nanotechnology.
CO2	Understand the physics of information processing.
CO3	Understand quantum algorithms and quantum error correction.
CO4	Know the reversible computing.
CO5	Understand the basic architecture of quantum communication and key distribution.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Foundations of quantum and classical computing – quantum mechanics, reversible computation, and quantum measurement**,** quantum logic

Unit-II

Simple quantum protocols and algorithms – teleportation and superdense coding, the Deutsch-Jozsa and Simon's algorithm, Grover's quantum search algorithm, and Shor's quantum factoring algorithm, Shor's factoring algorithm and Grover's search algorithm

Unit-III

Foundations of quantum communication – noise and quantum channels, and quantum key distribution, quantum error correction, quantum communication and key distribution

Unit-IV

Reversible computation, charge recovery logic, adiabatic circuits, or adiabatic computing. Relation to thermodynamics, Physical reversibility, Logical reversibility

Text and reference books:

1. Lange K.-J., McKenzie P., Tapp A. (2000), "Reversible space equals deterministic space", Journal of Computer and System Sciences, 60: 354–367, doi:10.1006/jcss.1999.1672.

2. Perumalla K.S. (2014), Introduction to Reversible Computing, CRC Press.

MTNT5319-18	Business Analytics	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Business Analytics** is to equip the M.Tech. students with the concepts of business analytic that he/she needs for for developing a strong background if he/she chooses to pursue industrial research in Nanotechnology as a career.

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

CO1	Understand the role of business analytics within an organization.
CO2	Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
CO3	To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
CO4	To become familiar with processes needed to develop, report, and analyze business data.
CO5	Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit-II

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit-III

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling

Unit-IV

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit-V

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Unit-VI

Recent Trends: Recent trends in Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

Text and reference books:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.

2. Business Analytics by James Evans, persons Education.

MTNT5320-18	Industry Safety	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Industry Safety** is to equip the M.Tech. students with the concepts of maintenance engineering that he/she needs for developing a strong background if he/she chooses to pursue industry as a career.

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

CO1	Understand basics of Industrial safety
CO2	Learn Fundamentals of maintenance engineering
CO3	Understand Wear and Corrosion and their prevention
CO4	Learn methods of Fault tracing
CO5	Learn concepts of Periodic and preventive maintenance:

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

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

Unit-II

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

Unit-III

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

Unit-IV

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

Unit-V

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

Text and reference books:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.

2. Maintenance Engineering, H. P. Garg, S. Chand and Company.

3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.

4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

MTNT5321-18	Operation research	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Operation research is to equip the M.Tech. students with the concepts of operation research methods for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	apply the dynamic programming to solve problems of discreet variables
CO2	apply the dynamic programming to solve problems of continuous variables
CO3	apply the concept of non-linear programming
CO4	carry out sensitivity analysis
CO5	model the real world problem and simulate it.

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit -I

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

Unit-II

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

Unit-III

Nonlinear Programming Problem: Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit-IV

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

Unit -V

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

Text and references books:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008.

2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982. Model Curriculum of Engineering & Technology PG Courses [Volume-I] [328].

3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008.

4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009.

5. Pannerselvam, Operations Research: Prentice Hall of India 2010.

6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

MTNT5322-18	Cost Management of Engineering Projects	L-3,T-1,P-0	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Cost Management of Engineering Projects** is to equip the M.Tech. students with the concepts of managing engineering projects for developing a strong background if he/she chooses to pursue industry as a career.

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

CO1	Understand Strategic Cost Management Process
CO2	Understand Cost concepts for management of Projects
CO3	Learn about the various stages of project execution
CO4	Understand the basic of Cost Behavior and Profit Planning Marginal Costing
CO5	Understand Quantitative techniques for cost management

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Unit-I

Introduction: Introduction and Overview of the Strategic Cost Management Process.

Unit-II

Effective Cost: Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit-III

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

Unit-IV

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

Text and reference books:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi.

2. Charles T. Horngren and George Foster, Advanced Management Accounting.

3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting.

4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher.

5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

MTNT5314-18	Project	L-0,T-0,P-8	4 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Project Work is to train M.Tech. students with the application of concepts for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	design and carry out scientific experiments as well as accurately record and analyze the results of experiments and simulation studies
CO2	skilled in problem solving, critical thinking and analytical reasoning as applied to scientific and Technical problems.
CO3	clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.
CO4	explore new areas of research in physics and allied fields of nanoscience and nanotechnology.
CO5	appreciate the central role of physics in our society and use this as a basis for ethical behavior

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Project on Current Trends in Nanotechnology covering Synthesis Process, Fabrication and Characterization of nanomaterials and their applications in devices.

Note: Project is to be carried out and submitted within the stipulated time in consultation with the concerned guide of the candidate.

Semester-IV

MTNT5411-18	Dissertation	L-0,T-0,P-0	16 Credits

Pre-requisite: None

Course Objectives: The objective of the course on Project Work is to train M.Tech. students with the application of concepts for developing a strong background if he/she chooses to pursue research in Nanotechnology as a career.

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

CO1	design and carry out scientific experiments as well as accurately record and analyze the results of experiments.
CO2	skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
CO3	clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.
CO4	explore new areas of research in physics and allied fields of science and technology.
CO5	appreciate the central role of physics in our society and use this as a basis for ethical behavior

Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

Detailed Syllabus:

Dissertation on Current Trends in Nanotechnology covering Synthesis Process, Fabrication and Characterization of nanomaterials and their applications in devices.

Note: Dissertation work is to be carried out and submitted within the stipulated time in consultation with the concerned guide of the candidate.

Audit Course 1

MTNT5124-18	English for Research paper writing	L-2,T-0,P-0	0 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **English for Research paper writing**. is to equip the M.Tech. students with the concepts of English writing that he/she needs for writing research papers, research projects and reports for developing a strong background to engage in effective scientific writing in lifelong learning process.

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

CO1	write professional quality essays, critically evaluate, revise and edit their own writings.
CO2	use library and online resources, assess and cite those sources properly, wherever necessary.
CO3	edit their own writing as well as the writing of their peers, to produce a scientific research paper.
CO4	familiar with the terminology of the writing process.
CO5	will be amply prepared to be a responsible citizen in a globally interconnected and diverse society.

Detailed Syllabus:

1. Planning and Preparation, Word Order, Breaking up long sentences,Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

2 Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

3 Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

4 key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

5 skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

6 useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Reference Books:

1. The Norton Introduction to Literature, 12th edition.
2. Freshman Composition Course Packet, 2016 - 2017.
3. A Christmas Carol by Charles Dickens.

MTNT5125-18	Disaster Management	L-2,T-0,P-0	0 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Disaster Management** is to equip the M.Tech. students with the understanding of the basic concepts of Disaster Management that he/she needs for developing a lifelong learning skill.

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

CO1	To provide basic conceptual understanding of disasters and its relationships with development.
CO2	To gain understand approaches of Disaster Risk Reduction (DRR) and the relationship between vulnerability, disasters, disaster prevention and risk reduction.
CO3	To understand Medical and Psycho-Social Response to Disasters.
CO4	To prevent and control Public Health consequences of Disasters.
CO5	To enhance awareness of Disaster Risk Management institutional processes in India.

Detailed Syllabus:

Unit-I

Introduction: Disaster: Definition, Factors and Significance; Difference Between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

Unit-II

Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

Unit-III

Disaster Prone Areas in India Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics

Unit-IV

Disaster Preparedness and Management Preparedness: Monitoring of Phenomena Triggering A Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Unit-V

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

Unit-VI

Disaster Mitigation Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

Reference books:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

MTNT5126-18	Sanskrit for Technical Knowledge	L-2,T-0,P-0	0 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Sanskrit for Technical Knowledge** is to equip the M.Tech. students with the technical knowledge which has been express in Sanskrit that he/she needs developing a strong background of our rich ancient technical knowledge.

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

CO1	Understand the basic Sanskrit language
CO2	Learning of Sanskrit to improve brain functioning
CO3	Understand the Ancient Sanskrit literature about science & technology
CO4	enhancing the memory power
CO5	The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Detailed Syllabus:

Unit-I

Alphabets in Sanskrit,
Past/Present/Future Tense,
Simple Sentences

Unit-II
Order
Introduction of roots
Technical information about Sanskrit Literature

Unit-III
Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics.

Text and reference books:

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

MTNT5127-18	Value Education	L-2,T-0,P-0	0 Credits

Pre-requisite: Universal Human Values

Course Objectives: The objective of the course on **Value Education** is to equip the M.Tech. students with the concepts of value education that he/she needs for professional development for developing a strong background for lifelong learning process.

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

CO1	Learn about the importance of value education
CO2	Learn about the nature, society and larger systems
CO3	developing clarity of human relationships
CO4	Understand the relation between ethics and development of society
CO5	Sensitize towards issues in society and nature.

Detailed Syllabus:

UNIT I

Living in harmony as an individual

UNIT II

Establishing harmony in family

UNIT III

Building a society based on trust

UNIT IV

Understanding coexistence with rest of nature

Text and reference books:

1. Human Values and Professional Ethics by RR Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010.
2. Jeevan Vidya: E.K Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi.
5. On Education - The Mother.
6. Diaries of Anne Frank - Anne Frank.
7. Life and Philosophy of Swami Vivekananda.

Audit Course-2

MTNT5225-18	Constitution of India	L-2, T-0,P-0	0 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Constitution of India** is to equip the M.Tech. students with the concepts of political system in India that he/she needs for developing a strong background about fabric of the nation.

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

CO1	Learn about the perspective of the Constitution of India
CO2	Learn about the fundamental rights
CO3	Learn about the fundamental duties and legal status
CO4	Learn about the federal structure of India
CO5	Learn about the constitutional powers of important constitutional offices

Detailed Syllabus:

Unit-I

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working)

Unit-II

Philosophy of the Indian Constitution: Preamble**,** Salient Features

Unit-III

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom**,** Right against Exploitation**,** Right to Freedom of Religion**,** Cultural and Educational Rights, Right to Constitutional Remedies**,** Directive Principles of State Policy**,** Fundamental Duties.

Unit-IV

Organs of Governance: Parliament, Composition**,** Qualifications and Disqualifications Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications**,** Powers and Functions,

Unit-5

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation.

Panchayati raj: Introduction, PRI: Zila Panchayat, Elected officials and their roles, CEO Zila Panchayat: Position and role. Block level: Organizational Hierarchy (Different departments),

village level: Role of Elected and Appointed officials, Importance of grass root democracy

Unit-VI

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

Text and reference Book:

1. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.
2. The Constitution of India, 1950 (Bare Act), Government Publication.

MTNT5226-18	Pedagogy studies	L-2,T-0,P-0	0 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Pedagogy studies** is to equip the M.Tech. students with the concepts of teaching methodology that he/she needs for developing a strong background skill required for academic career.

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

CO1	Teaching: culture and education in present-day society
CO2	Learn about teaching strategies
CO3	Learn about Strategies for learning and participation at university
CO4	Learn about Comparative education
CO5	Understand importance of Research, development and innovation of the curriculum

Detailed Syllabus:

Unit-I

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.** Overview of methodology and Searching.

Unit-II

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Unit-III

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical Practices, Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Unit-IV

Professional development: alignment with classroom practices and follow up support, Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes

Unit-V

Research gaps and future directions, Research design**,** Contexts**,** Pedagogy**,** Teacher education, Curriculum and assessment, Dissemination and research impact.

References:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2):245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.

MTNT5227-18	Stress management of Yoga	L-2,T-0,P-0	0 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Stress management of Yoga** is to equip the M.Tech. students with the concepts of stress management that he/she needs for developing a strong background for lifelong healthy learning.

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

CO1	Understand the importance of life management skills
CO2	achieve overall health of body and mind
CO3	Learn about the effects of stress on body
CO4	Learn about yoga for enhancing quality of life
CO5	Importance of engaging in life long learning process

Detailed Syllabus:

Unit-I

Definitions of Eight parts of yog. (Ashtanga)

Unit-II
Yam and Niyam.
Do`s and Don't's in life.
i) Ahinsa, satya, astheya, bramhacharya and aparigraha
ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Unit-III
Asan and Pranayam
i) Various yog poses and their benefits for mind & body
ii)Regularization of breathing techniques and its effects-Types of pranayam

References:

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

MTNT5228-18	Personality Development through life enlightenment skills	L-2, T-0, P-0	0 Credits

Pre-requisite: None

Course Objectives: The objective of the course on **Personality Development through life enlightenment skills** is to equip the M.Tech. students with the basic of personality development skills that he/she needs for developing a strong background if he/she chooses to pursue progress in career.

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

CO1	Understand the importance of improving personality
CO2	achieve the highest goal happily
CO3	become a person with stable mind, pleasing personality and determination
CO4	Learn about the Time Management
CO5	awaken wisdom in students

Detailed Syllabus:

Unit-I

Neetisatakam-Holistic development of personality: Verses- 19,20,21,22 (wisdom); Verses- 29,31,32 (pride & heroism); Verses- 26,28,63,65 (virtue); Verses- 52,53,59 (dont's); Verses- 71,73,75,78 (do's)

Unit-II

Approach to day to day work and duties: Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48, ;Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17,

23, 35,; Chapter 18-Verses 45, 46, 48.

Unit-III

Statements of basic knowledge.: Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68; Chapter 12 -Verses 13, 14, 15, 16,17, 18; Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42,; Chapter 4-Verses 18, 38,39; Chapter18 – Verses 37,38,63

References:

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication
2. Department), Kolkata
3. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath,
4. Rashtriya Sanskrit Sansthanam, New Delhi.