MANONMANIAM SUNDARANAR UNIVERSITY
TIRUNELVELI
PG-COURSES–AFFILIATED COLLEGES

Course Structure for M.Sc. Nanoscience and Nanotechnology

(Choice Based Credit System)

(With effect from the academic year 2021-2022 onwards)

VISION AND MISSION OF THE UNIVERSITY

VISION

" To provide quality education to reach the unreached "

MISSION

- To conduct research, teaching and outreach programmes to improve conditions of human living
- To create an academic environment that honours women and men of all races, caste, creed, cultures and an atmosphere that values intellectual curiosity, pursuit of knowledge, academic freedom and integrity
- To offer a wide variety of off-campus educational and training programs, including the use of information technology, to individuals and groups.
- To develop partnership with industries and government so as to improve the quality of the workplace and to serve as catalyst for economic and cultural development
- To provide quality / inclusive education, especially for the rural and un-reached segments of economically downtrodden students including women, socially oppressed and differently abled

Sem. (1)	Sub. No. (2)	Subject Status (3)	Subject Title (4)	Contact Hrs./Week (5)	Credits (6)
I	1	Core-1	Mathematical Physics	6	4
	2	Core– 2	Quantum Mechanics	6	4
	3	Core-3	Solid State Physics	5	4
	4	Core-4	Electronics-Theory	5	4
	5	Core– 5	General Physics–Practical	4	2
	6	Core-6	Electronics-Practical	4	2
II	7	Core-7	Fundamentals of Nanoscience	5	4
	8	Core-8	Synthesis of Nanomaterials	5	4
	9	Core-9	Properties of Nanomaterials	4	4
	10	Core-10	Numerical Methods	4	4
	11	Core-11	Field Work	4+	3
	12	Core– 12	Synthesis of Nanomaterials- I–Practical -3	4	2
	13	Core-13	Characterization of Nanomaterials-I–Practical -4	4	2
III	14	Core-14	Characterization of Nanomaterials	6	4
	15	Core-15	Nanoelectronics	6	4

	16	Core-16	Basics of Nanobiotechnology	5	4
	17	Core-17	Research Methodology	5	4
	18	Core-18	Synthesis of Nanomaterials- II–Practical -5	4	2
	19	Core-19	Characterization of Nanomaterials-II–Practical-6	4	2
IV	20	Core-20	Magnetic Nanomaterials and Devices	4	4
	21	Core-21	Nanosensors	4	4
	22	Core-22	Nanomedicine and Drug Delivery	4	4
	23	Core-23	Ethical Aspects of Nanotechnology	4	4
	24	Elective-1	Carbon Nanostructures and Applications	3+	3
	25	Core-24	Project	11	8

EVALUATION SCHEME

Duration: Two years Full Time (Each year having Two semesters)

Medium of Instruction and Examinations: English

Eligibility Norms for admission:

A candidate shall be eligible for admission to Nanoscience and Nanotechnology (M.Sc) course if he/she has obtained Bachelor's degree (B.Sc., Nanoscience, Nanochemistry, Physics, Chemistry, Electronics, Applied Chemistry, Organic chemistry, Inorganic chemistry, Physical Chemistry, Analytical chemistry, Industrial Chemistry, Textile Chemistry, Na nobiology, Nanophysics, Nanobiochemistry, Nanoscience and Nanotechnology, Life Science in equivalent degree recognized by our university with a minimum of fifty percent (50%) marks (For SC/ST-Pass).

M.Sc Nanoscience and Nanotechnology curriculum is divided and studied in 4 semesters. The external evaluation will be based on the examination to be conducted by the university at the end of each semester. Practical examinations will be conducted at the end of each semester.

A. Each paper carries an internal component

B. There is a pass minimum of 50% for P.G. external and overall components

Theory External: Internal Assessment = 75:25

Practical External: Internal Assessment = 50:50

C. Internal Assessment

Internal marks for Theory shall be allocated in the following manner.

The average of the best two tests from three compulsory tests	15 Marks
Seminar	05 Marks
Assignment	05 Marks
Total	**25 Marks**

Note: Each test will be of one hour duration.

D. Practical

Duration of Practical Exam: 6 hours

Internal marks for practical shall be allotted in the following manner.

Experimental work	20 Marks
Record	10 Marks
Model Test	20 Marks
Total	**50 Marks**

E. Project Work/Field Work

Components	Marks
Project Report/Field Work Report	75 Marks
Viva -Voce	25 Marks
Total	**100 Marks**

Note:

i. Students should carry out individual project only.

ii. Project report/ Field Work Report will be evaluated by the guide and Viva-Voce will be conducted by both the External examiner and the Guide at the end of the semester.

F. The question paper pattern for all theory papers shall be as follows.

Duration of Exam: 3 Hours

Section	Type of questions	Mark
Part-A	Multiple choice question (Two question from each unit compulsory)	1×10=10 Marks
Part-B	Internal Choice questions (One question from each unit: either/or)	5×5=25 marks
Part-C	Internal Choice questions (One question from each unit: either/or)	8×5=40 marks
	Total	**75 Marks**

Program Outcomes (PO)

PO – 1: Provide understanding of physical, chemical and biological principles in the multi-disciplinary field of nanoscience and nanotechnology

PO – 2: Develop skills on the synthesis of nanomaterials and fabrication of micro- and nano-structures

PO – 3: Familiarize the graduates with the advanced nanoscale characterization techniques and develop the analytical ability

PO – 4: Enable graduates with professional, scientific research, and computational skills for employment in industries, R & D centres and higher education

PO- 5: Prepare the graduates to take individual and team work responsibilities in a multidisciplinary environment

Program Specific Outcomes (PSO)

PSO – 1: Ability to understand materials and their properties at the atomic and nanometer scales, including an understanding of the intimate relationship between the scale and the properties of materials

PSO - 2: Ability to apply the learnt nanotechnology principles, analyze, evaluate and design advanced systems & processes

PSO - 3: Ability to employ the acquired skills in nanotechnology for the benefit of self and society

PSO-4: The methodology required for planning and execution of experiments.

PSO-5: The analysis and interpretation of experimental results.

PSO-6: Demonstrate the ability to plan, undertake, and report on a project of original work.

PSO-7: Develop communication skills, both written and oral, for specialized and nonspecialized audiences.

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MATHEMATICAL PHYSICS L T P C

6 0 0 4

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

CO1: Comprehend the concept of Vector analysis along with Applications of Vectors.

CO2: Conceptualize Vector space and study of Dirac Delta Function and Applications.

CO3: Analyze characteristics of matrices and its different types and also solve linear equations.

CO4: Solve Linear Differential equations and discuss the properties of special functions.

CO5: Realize the basics of Tensor Analysis and its applications.

Preamble: This course enables the students to understand the various mathematical methodsused in Physics. The paper needs a basic knowledge in mathematics and the learners areexpected tocome out with theabilityto applymathematics to solveproblems in physics.

Unit I: **Vector differential operator:** Gradient, Curl, Divergence and Laplacian and vector operators in curvilinear coordinated (Rectangular, Spherical polar and cylindrical polar coordinates)-Linear independence of vectors-Schmidst orthogonalization process–Directional Derivatives -Eigen values and eigen vectors of matrix (18L)

Unit II: **Fourier transform:** Inverse Fourier transform-Properties of Fourier transform-Convolution theorem-Laplace transforms-Inverse Laplace transform-Laplace transform of derivatives and integrals-Tensors-Basic ideas of covariant, contravarient and mixed tensors – Cramer's Rule. (20L)

Unit III: **Complex variables:** Analytic functions-Cauchy-Riemann equations Cauchy's integral formula-Cauchy's residue theorem and evaluation of integrals-Contour integration. (16L)

Unit IV: **Differential equation:** Legendre polynomials-Generating function-Recurrence relations-Hermite polynomials-Generating function-Recurrence relations-Bessel function-Generating function-Recurrence relations-Spherical Bessel function. (18L)

Unit V: **Partial differential equations:** Solution of Laplace's equation in rectangular, spherical polar and cylindrical polar coordinates-Heat flow-Equation of motion for vibrating strings-Vibration of a rectangular membrane. (18L)

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Mapping of Course Outcomes to Program Outcomes:

C O	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	
CO1	M	M	H	H	M	H	M	H	M	H	M	H	K1
CO2	M	M	H	H	M	H	M	H	M	H	M	H	K2
CO3	M	M	H	H	M	H	M	H	M	H	M	H	K3
CO4	M	M	H	H	M	H	M	H	M	H	M	H	K4
CO5	M	M	H	H	M	H	M	H	M	H	M	H	**K5**

Books for study and References:

1. Applied Mathematics for Physicist and Engineers by L.A.Pipes and L.R.Harwill

2. Mathematics for Scientists and Engineers by H.Cohen

3. Mathematical Physics by Sathya Prakash

4 'Mathematical Physics' by K.Chattopadhyay
5. 'Advanced Engineering Mathematics' by E.Kreyszig
6. M.R.Spiegelin Schaums, Outline Series (i) Vector analysis, (ii) Complex variables, (iii) Laplace transforms, (iv) Matrices,(v) Differential equations, etc.

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QUANTUM MECHANICS

LT P C
6 0 0 4

CO1: Better understanding of the mathematical foundations of angular momentum of a system of particles.
CO2: Apply the perturbation theory to scattering matrix and partial wave analysis. Compare and analyze the different approximation methods
CO3: Applications of various approximation methods in solving the Schrodinger equation.
CO4: Understand the concept of Scattering cross-section, scattering amplitude of Born approximation and partial wave analysis method
CO5: Grasp the central concept and principles of relativistic Quantum Mechanics and solve problems.

Preamble: This course imparts knowledge about wave functions and Schrodinger equationsand matrix mechanics, Heisenberg uncertainity principle and different operators involved inquantum mechanics. Basics of quantum mechanics are essential. Methods of solving somemicroscopicproblems usingquantum mechanicalideasarestudied

Unit I: De Broglie's hypothesis: The motion of a free wave packet; classical approximationand the uncertainty principle- Uncertainties introduced in the process of measurement- The quantization of fields-Schrodinger equation for afree particle(one and three dimensions)-The operator correspondence and the schrodinger equation for a free particle subject to forces. Physical interpretation of Ψ: Normalization and probability interpretation (20L)

Unit II: **Stationary states:** The time-independent schrodinger equation – A particle in thesquare well potential- Bound states ina square well (E<O and E>O) – The square potentialbarrier- Multiple potential well: Splitting of energy levels; Energy bonds- The fundamentalpostulatesof wavemechanics. (16L)

Unit III: Adjoint Operators: The adjoint of an operator and self-adjointness-The eigen value problem; Degeneracy- Eigen values and eigen functions of self –adjoint operators-The Dirac delta function- Observables: Completeness and normalization of eigen functions - Physical interpretation of eigen values, eigen functions and expansion coefficient-Sphericalharmonics- physical interpretation-Angular momentum in stationary states of systems with spherical symmetry. (18L)

Unit IV: **Perturbation theory for discrete levels:** Equations in first orders of perturbation theory – The effect of anelectric field on the energy levels of an atom (Stark effect) – Twoelectron atoms- The variation method- Upper bound on ground state energy - The hydrogenmolecule`. (18L)

Unit V: **Angular momentum:** The eigen value spectrum-Matrix representation of Jinthe /jm>basis–Spinangular momentum-Nonrelativistic Hamiltonian including spin-Addition of angular momenta- Clebsch- Gordan coefficients- Spin wave function for a system of two spin-1/2particles-Identical particles with spin-Addition of spin and orbital angular momenta. (18L)

Mapping of Course Outcomes to Program Outcomes:

C O	Correlation level											Cognitive level
	PO					PSO						
	1	2	3	4	5	1	2	3	4	5	6	7	
CO1	H	M	H	H	M	H	M	H	M	H	M	H	K1
CO2	M	M	H	H	L	H	M	H	M	H	M	H	K2
CO3	H	M	H	H	M	H	M	H	M	H	M	H	K3
CO4	M	M	H	H	M	H	M	H	M	H	M	H	K4
CO5	H	M	M	M	M	H	M	H	M	H	M	H	**K5**

Book for Study and References:

1. A textbook of Quantum Mechanics by P.M.Mathews and K.Venkaresan
2. Quantum Mechanics(3^{rd}edn) by L.I.Schiff
3. Introductory Quantum Mechanics (4^{th}edn) by R.L.Liboff
4. Quantum Mechanics by P.J.E.Peebles

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SOLID STATE PHYSICS LTPC

5 0 0 4

CO1: Determine the structure factors of fundamental crystal lattices
CO2: analyze the X-ray diffraction patterns of simple crystal structures
CO3: classify the different crystal binding forces and explain the vibrations of lattice structures
CO4: Able to explain various magnetic phenomena and describe the different types of magnetic ordering (Diamagnetism, Paramagnetism, Ferromagnetism) based on the exchange interaction.
CO5: Differentiate between type-I and type-II superconductors and score on the theoretical explanation of super conductivity viz Cooper pairs and BCS theory.

Preamble: Objective of this paper is to introduce crystals and to provide an understanding about different types of materials. The paper needs a basic knowledge of semiconductors and superconductors and the learners are expected to get some ideas on Materials Research.

Unit I: **Introduction of crystal system:** Periodic arrays of atoms- Fundamental types of lattices- Index system for crystal planes –Simple crystal structures – Diffraction of waves by crystals–Scattered wave amplitude–Brillouin zones–quasi crystals. (15L)

Unit II: **Types of crystals:** Ionic crystals – covalent crystals – Metals –Hydrogen Bonds – Vibration of crystals with monoatomic Basis – Two atoms per primitive basis – Quantization of elastic waves –Phonon momentum–In elastic scattering by Phonons. (15L)

Unit III: **Energy levels in various dimension:** Energy levels in one dimension - Effect of Temperature on the Fermi- Dirac distribution – Free electron gas in three dimension – Heat capacity of the electron gas – Electrical conductivity and Ohm's law – Motion in Magnetic fields- Hall Effect. (15L)

Unit IV: Semiconductors crystals: Band gap – Equations of motion – Intrinsic carrier concentration–Impurity conductivity–Thermo electric effects–Semimetals–Superlattices –Optical reflectance– Excitons. (15L)

Unit V: Superconductors: Superconductivity Type I & Type II superconductors–Meissner effect –London equation – BCS theory–Dc & Ac Josephson effects. 15L)

Mapping of Course Outcomes to Program Outcomes:

C O	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	
CO1	H	M	H	H	M	H	M	H	M	M	M	H	K1
CO2	M	M	H	H	L	H	M	H	M	M	M	H	K2
CO3	H	M	H	H	M	H	M	H	M	M	M	H	K3
CO4	M	M	H	H	M	H	M	H	M	H	M	H	K4
CO5	H	M	M	M	M	H	M	H	M	H	M	H	**K5**

Books for study and References

1. Introduction to Solid state Physics (7^{th}edn.) by C.Kittel
2. Solid State Physics by S.O. Pillai

3. Solid State Physics by P.K.Palanisamy

4. Solid State Physics by A.J.Dekkar.

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ELECTRONICS LTP C

5 0 0 4

Course Outcomes: At the end of the Course, the Student will be able to:
CO1: Construct circuits using Integrated circuits, op-amps.
CO2: Use the appropriate measuring device to record the data with precision
CO3 : To comprehend and compare the different characteristics of semiconductor devices and their various applications
CO4: Understand the operation of several digital circuits both combinational and sequential
CO5: Solve simultaneous equations, perform D/A conversion using Op-amp

Preamble: This course provides an understanding of Boolean algebra and digital circuits. The paper needs a basic knowledge in solid state electronics and the learners are expected to gain knowledge to design electronic circuits.

Unit I: Boolean Algebra: Postulates and theorems of Boolean algebra, De-Morgan's Theorem, Reducing Boolean expressions, Logic Gates: Positive and Negative Logic, Basis Logic Gates: AND, OR, NOT (symbols, truth-table, circuit diagram, working); NAND, NOR, EX-OR, EX-NOR (Symbols, truth-table) (17L)

Unit II: Minimization Techniques: Introduction, SOP and POS form of Boolean functions, Karnaugh Map simplifications (upto 4 variables), implementations of SOP and POS form using NAND and NOR gates. (13L)

Unit III: OP AMP and Applications: Characteristics and Parameters – DC Analysis of ICOPAMP-Applications of OPAMP-Instrumentation amplifier–Analog Multiplexer – Integrator– Differentiator. (15L)

Unit IV: Timer, VCO, PLL, and Applications: Timer-555 Timer–Internal Architecture and Working – Modes of Operation: Monostable and Astable operation –Applications-Voltage Control Oscillator–IC566-PLL Concept–PLLIC565–Application (15L)

Unit V: Electronic Measurement and Control: Sensors and Transducers–Measurement and Control- Signal Conditioning and Recovery – Impedance Matching –Amplification (OP Amp based Feedback Amp, Instrumentation Amp) – Noise and NoiseSources (15L)

Mapping of Course Outcomes to Program Outcomes:

C O	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	
CO1	H	M	H	H	M	H	M	M	H	M	M	H	K1
CO2	M	M	H	H	M	H	M	M	H	M	M	H	K2
CO3	H	M	H	M	M	H	M	M	H	M	M	H	K3
CO4	M	M	H	M	M	H	M	H	H	H	M	H	K4
CO5	H	M	M	M	M	H	M	H	H	H	M	H	**K5**

Books for Study and References:

1. Integrated Electronics Analog and Digital Circuits and Systems, Second Edition, Jacob Millman, Christos C Halkias, Chetan Parikh, Tata McGraw Hill Education Private Limited, New Delhi.
2. Analog and Digital Electronics, U.A.Bakshi, A.P.Godse, Technical Publications, Pune.
3. Introduction to Semiconductor Devices M.S.Tyagi, John Wiley and Sons.
4. Electronic instrumentation, P.P.L.Regtian, VSSD Publications, 2005.

General Physics LTPC

0042

Preamble: To learn physics concepts through experiments.

Any 5 Experiments

1. Ultrasonic Interferometer
   Determination of velocity of ultrasonic sound in the given liquid and compressibility of the liquid.
2. Cauchy's Constant
   a) Determination of Cauchy's Constant by spectrometer.
   b) Verification of the experimental result with graphically obtained value.
3. Young's Double Slit
   Determination of wave length of the light source or width of the double slit using Laser Source for a) Standard Kit b) lab/custom made double slit.
4. Curve fitting (Straight line, Exponential curve and parabolic curve for the given datasets)
5. Mutual Inductance
   Determination of mutual inductance between a pair of coils. Study of variation of mutual inductance for various distances and angles between the coils and determination of coefficient of coupling in each case. Graphical determination of break in coupling for distance and angle.
6. Hall effect, carrier concentration and magneto resistance measurements
7. Optical Fibre Characteristics
   Determination of
   a) Numerical aperture and acceptance angle
   b) Attenuation in the fibre and
   c) Loss due to air gaps and coupling

ELECTRONICS LTPC

00 4 2

Preamble: To learn electronic concepts through various circuits.

Any 5 Experiments

1. NAND and NOR as universal building block.

2. UJT Characteristics and Relaxation Oscillator
   Characteristics study of UJT – construction of a relaxation oscillator, using UJT to produce the saw tooth wave. Frequency response of the output for various R and C values.
3. OP-AMP Adder and Subtractor
4. OP-AMP Differentiator and Integrator
5. Code Converters
   Construction of Code converters using ICs-Tabulate input and output for various decimal numbers
   a) BCD to Excess-3 c) BCD to Gray
   b) Excess -3 to BCD d) Gray to Excess-3
6. Verify Demorgan's law using logic gates.
7. Half Adder and Full Adder-IC

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FUNDAMENTALS OF NANOSCIENCE LTPC

5004

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

CO1: Remember key concepts of nanoscience and nanotechnology. The Basic concept, methods and techniques of nanoscaffolds

CO2: Understand how nanotechnology can be tailored and used for biomedical purposes, catalyst.

CO3: explain the properties of nanomaterials are size dependent. Predict the behavior of nanomaterials

CO4: demonstrate the approaches to design and fabrication of nanomaterials

CO5: summarise the scientific method and justify its use in science

Preamble: This course provides an understanding of nanoscience and nanotechnology. Thepaper need a basic knowledge in nano sized materials and the learners are expected to gainknowledgeabout nanoscience.

Unit I: **Limitations of nanoscience:** Basic problems and limitations – Opportunities at theNanoscale – time and Length scale in structures – energy Landscape – basic intermolecular forces – interdynamic aspects of intermolecular forces – Evolution of Band structures andFermiSurface. (16L)

Unit II: **Background to Nanotechnology:** Scientific revolutions – Types of Nano structure and Nanomachines–atomic structure–molecules & phases–energy –molecular and atomic size– surfaces and dimensional space–top down and bottom up. (14L)

Unit III: Nanosystem: Definition of a nano system – dimensionality and size dependentphenomena; Quantum dots Nanowires and Nanotubes – size dependent variation in Magnetic, electronic transport, reactivityetc. (14L)

Unit IV: Effects of forces I: Forces between atoms and molecules, particles and grainboundaries, surfaces – strong intermolecular forces – Vander Waals and electrostatic forcesbetween surfaces – Similarities and differences between intermolecular and inter particleforces–weakintermolecularforcesandtotalintermolecularpairpotentials. (16L)

Unit V: Effects of forces II: Forces between salvation, hydration; polymers at surfaces; adhesion – thermodynamics of self assembly; micells, bilayers, vesicles – bionanomachines – biological membranes. (15L)

Mapping of Cos to POs and PSOs

CO	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	L	L	L	L	M	L	L	L	L	H	M	L	L	K1
CO2	L	L	L	L	M	L	L	L	L	H	M	L	L	K2
CO3	L	L	L	L	M	L	L	L	L	H	M	L	L	K3
CO4	L	L	L	L	M	L	L	L	L	H	M	L	L	K4
CO5	L	L	L	L	M	L	L	L	L	H	M	L	L	K5

Books for Study and References:

1. Nanotechnology: basic science and emerging technologies – Mick Wilson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press(2005).
2. Amorphous and Nanocrystalline Materials: Preparation, Properties and Applications, A.Inoue, K.Hashimoto (Eds.,) (2000)
3. Understanding Nanotechnology, Scientific American editors at Scientific American, Warner Books (2002).
4. www.nanonet.rice.edu\intronanosci\
5. www.acclab.helsinki.fi\~knordlun\nanotiede\
6. Introduction to Nanotechnology by Charles P.Poole, Frank J.Owens, Wiley–Interscience (2003).
7. Nanotechnology: A Gentle Introduction to the Next Big Idea, Mark A.Ratner, Daniel Ratner, Mark Ratner, Prentice Hall PTR; 1st edition(2002)
8. Nano: The Essentials by T.Pradeep

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SYNTHESIS OF NANOMATERIALS L T P C

5 0 04

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

CO1: Understand the basic and advanced concepts of nanomaterial preparations.

CO2: Understand the importance of synthesis method addressed in the material properties and investigate the various factors influencing the properties of nanomaterials.

CO3: Gain expertise in optimizing the synthesis methodology and will be able to fabricate device architectures and new nanomaterials with novel biological activity.

CO4: Illustrate the Synthesis of nanomaterials by biological methods.

CO5: Methods for the fabrication through lithography techniques.

Preamble: This course facilitates an understanding of various synthesis methods to fabricatenanomaterials. This paper gives knowledge in the preparation of nanomaterials. The learners are expected to come out with the ability to use the synthesis methods to prepare nanomaterials.

Unit I: Nano outline: Introduction – Various preparation techniques – basic concepts ofnanostructured materials – nucleation – nano particle transport in low density media – vapour nano phase thermodynamics–aggregate formation (14L)

Unit II: Film deposition methods: Introduction – fundamentals of film deposition –thermal evaporation – Spray pyrolysis, Flame pyrolysis – molecular beam epitaxy – pulsed laser deposition – Sputter deposition – Chemical vapour deposition – Langmuir Blodgelt films. (16L)

Unit III: Sol-gel processing: – fundamentals of sol-gel process- sol- gel synthesis methodsfor oxides – other inorganic and nano composites – the Pecheni method – silica gel – zirconia and Yttriumgel–alumino silicate gel –polymer nanocomposites. (15L)

Unit IV: **Types of nanotubes:** formation of nanotubes – methods and reactants – arcing in the presence of cobalt – laser methods – ball milling – chemical vapour deposition methods – Catalytic route– Properties of nanotubes – Plasma arcing–electrodeposition (16L)

Unit V: **synthesis of special nanomaterials:** Introduction–Micro and meso porous materials – Core – shell structures – Organic – Inorganic Hybrids – Nanocomposites and nano grained materials. (14L)

Mapping of Cos to POs and PSOs

CO	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	L	L	L	H	M	L	L	L	L	H	M	L	L	K1
CO2	L	L	L	H	M	L	L	L	L	H	M	L	L	K2
CO3	L	L	L	H	M	L	L	L	L	H	M	L	L	K3
CO4	L	L	L	H	M	L	L	L	L	H	M	L	L	K4
CO5	L	L	L	H	M	L	L	L	L	H	M	L	L	K5

Books for study and References:

1. www.eng.uc.edu\~gbeaucag\classes\NanoPowder.html
2. Nanoelectronics and information technology: Advanced electronic materials and novel devices (2nd edition), RainerWaser (Ed.), Wiley-VCH Verlag, Weiheim(2005).
3. Recent Advances in the Liquid- phase synthesis if inorganic nanoparticles, BrainL.Cushing, Vladimir L.Kolesnichenko, CharlesJ.O`Connor, ChemRev. 104 (2004) 3893-3946.
4. Nano composite science and technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun,Wiley-V CH Verlag, Weiheim (2003)
5. Amorphours and Nanocrystalline Materials: Preparation, Properties and Applications, A.Inoue, K.Hashimoto (Eds.,)(2000).
6. Nanostructures and Nanomaterials–Synthesis, Properties and Applications by Guozhong cao.

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Properties of Nanomaterials LT PC
4 0 04

CO-1: Analyze fundamentals of nanotechnology, different classes of nanomaterials and their sizes and dimensions
CO-2: Relate the physical properties of nanostructured material
CO-3: Describe various magnetic properties of nanomaterials
CO-4: Distinguish various characterization techniques involved in nanamaterial
CO-5: Demonstrate skills required for application of nanomaterials.

Preamble: This course facilitates an understanding of various properties of nanomaterials such as electrical, magnetic, optical, mechanical and thermal properties. The learners are expected to come out with the ability to use this property for their research work.

Unit I: Electrical and Dielectric properties

Electrical: Temperature Coefficient of Resistance–Resistivity–Arrhenius Relation–Activation Energy; Dielectrics: Types of Polarization–Dielectric Constant–Dielectric Loss–Dielectric Breakdown–Double Schottky potential Barrier Height Model. (14L)

Unit II: **Magnetic properties**

Origin of Magnetism in material – Classification – Magnetic Moment – Magnetic Hysteresis –Magnetostriction – Curie Transition – Neel Temperature –Giant and Colossal Magnetoresistance–Superparamagnetism–Magnetic phenomena at Nanoscale. (11L)

Unit III: **Opticalproperties**

Optical phenomena in Materials–Surface Plasmon Resonance–Bandgap tailoring–Burstein – Moss Effect – Direct and Indirect Transitions – Effective Mass Approximation Theory – Kubelka – Munk function – isobestic effect – Hyper, Hypso, Batho and Hypochromic effects –Fluorescence: Stoke shift. (13L)

Unit IV: **Mechanical properties**

Mechanical: Modes of deformation – Elastic and plastic deformation – Compressive strength-Mechanical stiffness–Fracture–Toughness–Superplasticity–Hardness–Micro-hardness –Fracture–Toughness –Indentation –Hall-petch Relation. (12L)

Unit V: **Thermal properties**

Thermal: Thermal conductivity–Expansion–Stress–Specific Heat Capacity–Glass Transition Temperatures–Melting-point Depression. (10L)

Mapping of Cos to POs and PSOs

CO	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	L	L	L	L	L	L	L	L	L	L	L	L	L	K1
CO2	L	L	L	L	L	L	L	L	L	L	L	L	L	K2
CO3	L	L	L	L	L	L	L	L	L	L	L	L	L	K1,K2
CO4	L	L	L	L	L	L	L	L	L	L	L	L	L	K2,K3
CO5	L	L	L	L	L	L	L	L	L	L	L	L	L	K2,K3

Books for Study and References:

1. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R.Rao, A.Mullar, A.K.Cheetham (Eds), Wiley-VCH Verlag, 2004.
2. Impedance spectroscopy: Theory, Experiment and applications, E.Barsoukov, J.R.McDonald, John Wiley & Sons Ltd, 2006
3. Nanostructures and nanomaterials: Synthesis, properties and applications, G.Gao Imperial College Press, 2006.

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LT PC

4 0 04

NUMERICAL METHODS

Preamble: This course facilitates an understanding of various approximation methods. Thepaper needs knowledge in mathematics and the learners are expected to come out with theability to use approximation methods to find solution to problems which do not have exactsolutions.

Unit I: Linearequations: Zeroes of linear and non-linear algebraic equations and transcendental equations – Iterative methods – Bi-section method – Regula – Falsi method – Newton – Raphson`s method – Convergence and error in the above methods – Birge – Vieta method and- Solution if simultaneous equations – Direct methods – Gauss elimination – Gauss – Jordan methods – Iterative methods – Gauss – Seidal and Gauss – Jacobi method for real symmetric matrices. (14L)

Unit II: Approximation methods: Lagrange and Newton interpolations–Linear interpolation–Truncation error bounds–Finite difference operators–Interpolating polynomials using finite differences–Least square approximation. (10L)

Unit III: Integral equations: Newton`s-cote`s formula – Trapezoidal rule – Simpson`s $1/3^{rd}$and $3/8^{th}$ rule – Error estimates – Gaussian quadrature – Gauss – Legendre –Numerical double integration. (11L)

Unit IV: Differential equations: Taylor`s series method – Euler`s and Runge-Kutta 2^{nd} and 4^{th} order methods – Predictor – Cornector methods – Adams- Moulten method – Milne`s method–Second order differential equations–Taylor`s series and Runge –Kutta methods. (12L)

Unit V :**Difference quotients:** Geometrical representation of partial difference quotients – Classification of partial differential equations of second order – Elliptic equations – solutionsof Laplaceequationsbyiteration–Parabolic equations–Poison`sequations. (13L)

Books for Study and References:

1. Numerical Methods for Scientific and Engineering Computation by M.K.Jain, S.R.K.Iyengar and R.K.Jain
2. Numerical Methods in Science and Engineering by M.K.Venkataraman
3. Introductory Methods of Numerical Analysis by S.S.Sastri
4. Applied Numerical Methods by A.Goudin and M.Boumahrat
5. Numerical Mathematical Analysis by J.B.Scarborough.

Field work (4+hours, 3 credits)

MSU / 2021-22 / PG –Colleges / M.Sc.(Nano Science and Nanotechnology) / Semester - II/ Ppr.no.23 / Practical-3

Synthesis of Nanomaterials-I L T P C

0042

Preamble: To learn the fabrication methods of nanomaterials.

Any 5 Experiments

1. Preparation of nanomaterials by co-precipitation method.
2. Nanostructured thin film preparation by using Dip coating method.
3. Nanostuctured thin film preparation by using solgel process.
4. Nanostuctured thin film preparation by using spray pyrolysis method.
5. Preparation of nanostructured thin film by using spin coating process.
6. Micro hardness studies on thin films
7. Preparation of polymer nanoparticles.

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Characterization of nanomaterials I

LTPC

0042

Preamble: To learn the different characterization techniques of nanomaterials.

Any 5 Experiments

1. X-ray powder diffraction pattern analysis (Lattice parameters determination of CdS nanoparticles.)
2. Everyday objects (Like pollen grain, hair etc.) and optical microscope.
3. DC conductivity measurement at various temperatures with two probe setup (activation energy estimation also)
4. Dielectric measurement at various temperatures for a fixed frequency (ε_r,tanδ and σ_{ac} determination)
5. Film thickness measurement using air wedge method.
6. Bandgap energy for a given UV-Vis–NIR data using Tauc's plot.
7. Degradation rate of a given nanoparticle by using photocatalytic studies.

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Characterization of Nanomaterials LTPC

6004

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

CO-1: Understand the basic concepts of Nanomaterials

CO-2: Apply the physics of modulus in Nanomaterials.

CO-3: Analyze the processing of Nanomaterials.

CO-4: Identify the characterization techniques of Nanomaterials

CO-5: Apply the Nanomaterials in optical fields

Preamble: This course enables the students to understand the various characterization methods such as diffraction, structural, mechanical and optical techniques. The paper needs abasic knowledge in different characterizations and the learners are expected to come out with the ability to choose proper characterization for their research work.

Unit 1: Diffraction techniques: Neutron and X-ray diffraction–Scherer formula–Dislocation density micro strain- comparison of X-ray and neutron powder pattern- macromolecular crystallography using synchrotron radiation-role for neutron scattering in nanoscience (18L)

Unit 2: Mechanical Characterization: Micro hardness –fatigue-failure stress and strain toughness-glass transition and relaxation behavior–abrasion and wear resistance, superplasticity-Nanoindentation. (18L)

Unit 3: Electron Microscopes: Scanning Electron Microscopes-Transmission Electron Microscopes- Scanning Probe Microscopy- Atomic Force Microscopy- Scanning Tunneling Microscope- Scanning Non linear Dielectric Microscopy- Nanomanipulator- Nanotweezers-XPS-ICP. (20L)

Unit 4: **Optics-Photonics of nanotechnology:** properties of light and nanotechnology-interaction of light with nano systems- absorbance, Surface plasma excitation, size dependent PL- nano holes and photons-imaging- solar energy absorbents using nano particles-nanotechnology and daylight–photonic crystals-waveguides and control of light paths.(20L)

Unit 5: Optical and antibacterial studies: UV-Vis-NIR spectrometer, bandgap measurement-FTIR spectrometer, principle and application–Photoluminescence spectrometer, principle and application – Cell culture – antibacterial studies – antimicrobial studies. (14L)

Mapping of Cos to POs and PSOs

CO	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	L	L	L	L	M	L	L	L	L	H	L	M	L	K1
CO2	L	L	L	L	M	L	L	L	L	H	L	M	L	K2
CO3	L	L	L	L	M	L	L	L	L	H	L	M	L	K3
CO4	L	L	L	L	M	L	L	L	L	H	L	M	L	K4
CO5	L	L	L	L	M	L	L	L	L	H	L	M	L	K5

Books for Study and References:

1. Nanotechnology: basic science and emerging technologies-Mick Ailson, Kamali Kannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005)
2. Nanocomposite science and technology, Pulickel M.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weiheim (2003).
3. 'Advanced X-ray Techniques in Research and Industries' by A.K.Singh (ed.)
4. 'Transmission Electron Microscopy of Materials' by G.Thomas
5. Physical Principles of Microscopy: An introduction to TEM, SEM and AFM by R.F.Egerton
6. 'Instrumental Methods of Analysis (7^{th}edn.)' by Willard, Merritt, dean and Settle
7. Scanning Electron Microscopy and X-ray Microanalysis' by J.Goldstein

MSU / 2021-22 / PG –Colleges / M.Sc.(Nano Science and Nanotechnology) / Semester - III/ Ppr.no.27 / Core-15

NANOELECTRONICS LTPC

6 004

Preamble: This course facilitates an understanding of challenges in nano electronics and togain knowledge about molecular electronics, single electron devices, nano computers andspintronics. The paper needs a basic knowledge about nano devices and the learners are expected to gain knowledge about nanoelectronics.

Unit I: Introduction of nanoelectronics: Recent past, the present and challenges – Future – Overview of basic nanoelectronics–Tools for micro and nano fabrication. (18L)

Unit II: **Molecular electronic component:** Characterization of Switches and complex molecular devices–Polyphenylene based molecular rectifying diode switches and technology. (18L)

Unit III: Single electron devices: Quantum mechanical tunnel devices – Quantum dots and quantum wires–Nanoelectronic and nanocomputer architectures and nanotechnology (18L)

Unit IV: **Nanocomputers:** Quantum dot cellular automata (QCA)–Single electron circuits –Molecular circuits–Nanocomputer architecture. (18L)

Unit V: Spintronics: Introduction, overview, history and background – Generation of spinpolarization – Theories of spin injection, spin relaxation and spin dephasing – Spintronic device and applications–Spinfilters–Spindiodes–Spintransistors. (18L)

Books for Study and References:

1 Nanoelectronics and Nanosystems: From Transistor to Molecular and Quantum Devices by K.Goseretal.
2. Concepts in Spintronics by S.Maekawa
3. Spin Electronics by D. Awschalom
4. From Atom to Transistor by S. Datta

MSU / 2021-22 / PG –Colleges / M.Sc.(Nano Science and Nanotechnology) / Semester - III/ Ppr.no.28 / Core-16

BASICS OF NANOBIOTECHNOLOGY LTPC

5 0 0 4

CO-1: Be aware with the principle of nanobiotechnology.

CO-2: Acquire the theoretical knowledge on toxicology assays

CO-3: Explain the theoretical principles of nanoparticles in cancer therapy.

CO-4: Evaluate and suggest suitable techniques for drug delivery system

CO5: Summarise the significance of nanoscale & its dimensions, in 3D bio printing

Preamble: This course enables the students to understand the various applications of nanobiotechnology. The paper needs a basic knowledge in nanobiotechnology, nanotherapeutics etc. The learners are expected to come out with the ability to choose properbiologicalapplications.

Unit I: Definition of Nanobiotechnology - Basic ideas - Applications – Future for Nanoparticles and their manufactures – Bioinspired Nanomaterials: Source, Production of inorganic nanoparticles and its applications, Plant Production of Nanoparticles and its applications.

(15L)

Unit II: Bioconjugation – Organic nanoparticles and its applications – Self-assembled nanostructure: Types, Methods - Bio-derived templates and their applications in nanobiotechnology. (15L)

Unit III: Biomaterials: Introduction – DNA aptamers – Nanoclusters – Bio sensor: Types, Methods, Fabrication and their applications. Nanoparticles in *in vitro* and *in vivo* imaging.

(15L)

Unit IV: **Nanotherapeutics:** Drug Nanocarriers, targeting and release, Vaccines, Immunmodulators. Nanomaterials for tissue engineering. Nanoenabled systems for–efficient delivery of pesticides, fertilizers and nutrients in crops. (15L)

Unit V: **Imaging – Animal models:** Live and in color- Sentinel lymph node mapping ofthe pleural space – A biomagnetic system for in vivo cancer imaging – Quantum dots for live cells–In vivo imaging and diagnostics. (15L)

Mapping of Cos to POs and PSOs

CO	Correlation level													Cognitive level
	PO					PSO								
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	L	L	L	L	H	L	L	L	L	H	L	L	L	K1
CO2	L	L	L	L	H	L	L	L	L	H	L	L	L	K2
CO3	L	L	L	L	H	L	L	L	L	H	L	L	L	K3
CO4	L	L	L	L	H	L	L	L	L	H	L	L	L	K4
CO5	L	L	L	L	H	L	L	L	L	H	L	L	L	K5

Books for Study and References:

1. Challa S.S.R.Kumar (Ed) Biological and pharmaceutical nanomaterial: Wiley–VCH Verlag GmbH & Co., KgaA.
2. Ninmeyer C.M, Mirkin C.A (Eds.,) 2005. Nanobiotechnology
3. H.S.Nalwa (Ed) Handbook of Nanostructured Biomateials and their applications in nanobiotechnology, American Scientific Publishers. 2005.
4. Subbiah Balaji (Ed) NanoBiotechnology, MJP Publishers, 2010.

MSU / 2021-22 / PG –Colleges / M.Sc.(Nano Science and Nanotechnology) / Semester - III/ Ppr.no.17 / Core-17

Research Methodology LTPC

5004

CO-1: To learn the basics of knowledge in research.

CO-2: Define and formulate the research problems

CO-3: Explain the needs for research designs.

CO-4: Execute the experimental data and research report

CO5: Summarise the ethical issues and environmental impacts

Preamble: This course enables the students to understand the fundamentals of research andthey gathered knowledge about execution and reporting of research. The paper needs a basicknowledge in research ethics and the learners are expected to come out with the ability to choose proper ideas about research.

Unit 1: Fundamentals of research

Definitions and characteristics of research- Research process and steps in it- Areas of research–Research methods vs methodology–characteristics of scientific methods-Motivation of objectives–Types of research–Descriptive vs Analytical, applied vs fundamental, Quantitative vs Qualitative, conceptual vs Empirical. (16L)

Unit 2: Formulation of research

Defining and formulating the research problem- Selecting the problem- Necessity of defining the problem – Importance of literature review in defining a problem – Literature review– Primary, secondary and tertiary sources-Reviews, treatise, monographs (14L)

Unit 3: Research Design

Basic principles – Need of research design – Features of good design- Important concepts relating to research design – Observation and facts, Laws and theories , prediction and explanation, induction, detection, development of models. (15L)

Unit 4: Execution and reporting research

Observation and collection of theoretical & experimental data-Methods of data collection–Comparison of data–Generalization and interpretation. Structure and components of scientific reports- Types of report – Technical reports and thesis –Different steps in the preparation – Layout, structure and language of thesis- Illustrations, figures and tables-Quotation and footnotes-Bibliography, referencing. (16L)

Unit 5: Research Ethics and publication of results

Environmental impacts-Ethical issues–plagiarism-Research Journals–Impact Factor-Citation index-reporting to journals–commercialization-copyright–royalty-intellectual property right stand patent law- trade related aspects of intellectual property rights-reproduction of published material-reproducibility and accountability. (14L)

Books for Study and References:

1. C.K.Research Methodology II Edn, - Methods and Techniques, New Age International, New Delhi(2004)
2. Garg, B.L., Kothari Karadia,R., Agarwal,F and Agarwal, An Introduction to Research Methodology, RBSA Publishers. U.K. (2002).
3. Sinha, S.C. and Dhiman, A.K., Research Metodology 2 Volumes, Ess Ess Publications, New Delhi.
4. S.Rajasekar, P.Philominathan and V.Chinnathambi, Research Methodology.

Mapping of Cos to POs and PSOs

CO	Correlation level													Cognitive level
	PO					PSO								
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	L	L	L	L	L	L	L	L	L	L	L	L	L	K1
CO2	L	L	L	L	L	L	L	L	L	L	L	L	L	K2
CO3	L	L	L	L	L	L	L	L	L	L	L	L	L	K3
CO4	L	L	L	L	L	L	L	L	L	L	L	L	L	K4
CO5	L	L	L	L	L	L	L	L	L	L	L	L	L	K5

MSU / 2021-22 / PG –Colleges / M.Sc.(Nano Science and Nanotechnology) / Semester - III/ Ppr.no.32 / Practical-5

Synthesis of Nanomaterials II LTPC

0042

Preamble: To learn the different types of techniques to prepare nanoparticles.

Any 5 Experiments

1. Mn_3O_4 nanopowder preparation by using the domestic microwave oven.
2. Nanostructured thin film preparation by using the chemical bath techniques.
3. B-H curve tracing and hysteresis loss determination (using vibrating sample magnetometer)
4. ZnO nanopowder preparation by using NaOH as capping agent.
5. Preparation of CdO nanoparticles by sol gel process.
6. Preparation of ZnO-CdO nanocomposites.
7. Preparation of ZnO nanoparticles by hydrothermal techniques.

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Characterization of Nanomaterials II LTPC

0042

Preamble: To learn the various characterization of nanoparticles.

Any 5 Experiments

1. Microstrain analysis for the given XRD pattern.
2. Dielectric constant ε_r at various temperatures with various frequencies.
3. DC conductivity measurement at various temperature with four probe setup (bandgap estimation also)
4. Photoluminescence measurement of semiconductor nanoparticles.
5. Impedance measurement and analysis using Cole-Cole Plot method.
6. Light scattering and particle size determination
7. UV-Vis–NIR spectrum recording and optical bandgap determination.

MAGNETIC NANOMATERIALS AND DEVICES

L T P C

4 0 04

CO-1: To learn the basics of magetism.

CO-2: Define the transport of electrons in magnetism

CO-3: Explain the function of nanomagnets.

CO-4: Evaluate the imaging of media

CO5: Discuss the properties of magnetic materials

Preamble: This course facilitates an understanding of magnetic effects of nanomaterials and devices. This paper contains fundamentals of magnetism, Lorentz microscopy, magnetic force microscopy and basic concepts of Kerr effect and Faraday Effect. The learners are expected to come out with the ability to gather knowledge about magnetic nanomaterials.

Unit I: **Fundamentals of Magnetization:** Introduction–Magnetic fundamentals– Spontaneous Magnetization and curie Temperature–Magnetic Parameters–Stoner–Wohlfarth threshold– Antiferromagnetic materials– Memory Fundamentals– Magnetic Storage Fundamentals. (12L)

Unit II: Spintronics: Electron Transport in Magnetic Multi – Layers – Spintronics – Spin Polarized Electron Tunneling – Interlayer Exchange Coupling – Spin Relaxation in Magnetic Metallic layers and Multilayers. (12L)

Unit III: **Nanomagnets:** Particulate Nanomagnets–Geometrical Nanomagnets–Fabrication Techniques Scaling–Imaging Magnetic Microspectroscopy–Study of Ferromagnetic & Antiferromagnetic Interfaces. (12L)

Unit IV: **Optical Imaging and magnetic media:** Lorentz Microscopy–Electron Holography of Magnetic Nanostrucrures–Magnetic Force Microscopy–Magnetic Data storage – Introduction –Magnetic Media –Properties – Materials Used – Write Heads –Read heads – Applications of optical imaging in magnetic media. (12L)

Unit V :**Magnetoresistance:**General – in Normal Metals and in Ferromagnetic Materials – Future of Magnetic Data Storage – Magnetic – Optics and Magneto – Optic recording – Kerr Effect–Faraday Effect .(12L)

Books for Study and Reference:

1. Advanced Semiconductor and organic Nano-techniques–Vo1I Hadis Morkoc, Academic Press, Londan (2003) ISBN 0125070616
2. Modern Techniques for Characterizing Magnetic materials Edited by Yimeizhu, Springer (2005) ISBN 1402080077
3. Magnetic Microscopy of Nanostructures Hans P.Oepen and H.Hopster, Springer (2004) ISBN3540401865
4. Ultrathin Magnetic Stuctures II–Fundamentals ofNanomagnetism JAC Bland and B.Heinrich, Springer (2004) ISBN3540219536
5. Magnetic Materials: Fundamentals and Device Applications Nicola Ann Spaldin, Cambridge University Press (2003) ISBN 0521016584.

Mapping of Cos to POs and PSOs

CO	Correlation level													Cognitive level
	PO					PSO								
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	H	H	H	H	H	H	H	H	H	H	H	H	H	K1
CO2	H	H	H	H	H	H	H	H	H	H	H	H	H	K2
CO3	H	H	H	H	H	H	H	H	H	H	H	H	H	K3
CO4	H	H	H	H	H	H	H	H	H	H	H	H	H	K4
CO5	H	H	H	H	H	H	H	H	H	H	H	H	H	K5

MSU / 2021-22 / PG –Colleges / M.Sc.(Nano Science and Nanotechnology) / Semester - IV/ Ppr.no.36 / Core-21

NANOSENSORS

LTPC
4004

CO-1: To learn the types of sensors.

CO-2: Define the basics of sensors

CO-3: Explain the biomedical needs of sensors.

CO-4: Evaluate the instrumentation of biomedical sensors

CO5: Summarise the surface Plasmon properties of sensors

Preamble: Objective of the course is to provide knowledge about the basics of micro andnano sensors. The students also studies about the various types of biosensors and surfaceplasmon resonance. The learners are expected to come out with the ability to choose proper ideas about nanosensor devices.

Unit I: Types of sensors: Micro and nano sensors – Fundamentals of sensors – Biosensor – Micro fluids MEMS and NEMS – Packaging and characterization of sensors – Methods of Packaging at zero level, dye level and first level. (12L)

Unit II: **Basic ideas of Sensors:** Sensors for aerospace and defence – Accelerometer – Pressure sensor – Night vision systems – Nano tweezers – Nano cutting tools – Integration of sensors with actuators and electronic circuitry. (12L)

Unit III: Biomedical applications of sensors: Biosensors – Generation of Biosensors – Immobilization characteristics – Applications – Conducting polymer based sensors – DNAbiosensors– Opticalsensors –Biochips. (12L)

Unit IV: Surface Plasmon resonance: Theory-Basics of instrumentation-From dip to Real time measurement-SPR Assay–the steps of an Assay-Determination of kinetic parameters. (12L)

Unit V: Surface Plasmon Biosensors: Applications: Resonant Mirror Biosensor-Resonant waveguide grating Biosensor–Dual polarization Interferometry biosensor. (12L)

Books for Reference

1. Sensors: Micro and Nanosensors, Sensor Market Trends (Parts 1 and 2) by H.Meixner
2. Nanoscience and Nanaotechnology: Novel Structure and Phenomena by P.Sheng (ed.)
3. Nano Engineering in Science and Technology: An Introduction to the World of Nano Design by M.Rieth

4. Between Technology and Science and Technology: Exploring an Emerging Field Knowledge Flows and Networking on the Nanoscale by M. S. Meyer
5. From Atom to Transistor by S. Datta

Mapping of Cos to POs and PSOs

CO	Correlation level													Cognitive level
	PO					PSO								
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	M	M	M	M	M	M	M	M	M	M	M	M	M	K1
CO2	M	M	M	M	M	M	M	M	M	M	M	M	M	K2
CO3	M	M	M	M	M	M	M	M	M	M	M	M	M	K3
CO4	M	M	M	M	M	M	M	M	M	M	M	M	M	K4
CO5	M	M	M	M	M	M	M	M	M	M	M	M	M	K5

NANOMEDICINE AND DRUG DELIVERY

LTPC

4004

CO-1: To learn the basics of nanomedicine and drug delivery.

CO-2: To understand the biopharmaceutical and drug delivery

CO-3: Explain the types of sensors.

CO-4: Evaluate the properties of nanocarriers

CO5: Summarise the application of nanocarriers in drug delivery

Preamble: This course facilitates an understanding of bio–pharmaceuticals and drug delivery. It also deals with the drug delivery to brain pharmaceutical nanocarriers in the treatment and imaging of inflection. The learners are expected to come out with the ability to choose proper ideas about medical applications.

Unit 1: **Prospect of Nanomedicine**: History of the idea – The Biological and MechanicalTraditions–Nanomedicine-Taxonomy–Bio-Pharmaceuticals-Implantable Materials-Implantable Devices-Surgical Aids-Diagnostic Tools-Genetic Testing-Imaging (12L)

Unit II: **Types of Sensors**: Chemical and Molecular Sensors- Displacement and Motion sensors-Force Nanosensors-Pressure sensing-Thermal nanosensors- Electric and Magnetic Sensing. (12L)

Unit III: **Nanocarriers:** Needs and Requirements-Nanoparticle Flow: Implications for Drug Delivery-Genetic vaccines: A Role for Liposomes-Polymer Micelles as Drug Carriers-Recent advances in Microemulsions as Drug Delivery Vehicles. (13L)

Unit IV: **Nanocapsules**: preparation, Characterization and Therapeutic Applications-Aerosols as Drug Carriers-Magnetic Nanoparticles as Drug Carriers – Nanomedicine for eye (Ophthalmology). (11L)

Unit V: **Applications Drug Delivery**: Delivery of Nanoparticles to the Cardiovascular System-Nanocarriers for the vascular Delivery of Drugs to the Lungs-Nanoparticulate Carriers for Drug Delivery to the Brain-Pharmaceutical Nanocarriers in Treatment and Imaging of Inflection. (12L)

Books for Study Reference

1. Nano Medicines Edited by Dr.Parag Diwan and Ashish Bharadwaj, Pentagon Press (2006) ISBN 81-8274-139-4
2. Nanoparticulates as Drug Carriers, Edited by Vladimir P.Torchilin, Imperical College Press, North Eastern University, USA (2006) ISBN 1-86094-630-5

Mapping of Cos to POs and PSOs

CO	Correlation level													Cognitive level
	PO					PSO								
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	M	M	M	M	M	M	M	M	M	M	M	M	M	K1
CO2	M	M	M	M	M	M	M	M	M	M	M	M	M	K2
CO3	M	M	M	M	M	M	M	M	M	M	M	M	M	K3
CO4	M	M	M	M	M	M	M	M	M	M	M	M	M	K4
CO5	M	M	M	M	M	M	M	M	M	M	M	M	M	K5

CAL ASPECTS OF NANOTECHNOLOGY LTPC

4004

CO-1: To learn the ethical issues of nanotechnology.

CO-2: Define the goals of nanotechnology in societal implications

CO-3: Explain the role of nanoparticles in environment.

CO-4: Execute the safest way of nanotechnology in environment

CO5: Summarise the methods of nanopurification

Preamble: This course enables the students to understand the various ethical considerations in nanotechnology. It also facilitates the safety of nanoparticles and their applications of purification. The learners are expected to come out with the ability to choose proper ideas about the aspect of nanotechnology.

Unit 1: **Ethical considerations:** advance of nanotechnology-The nature of ethics-Ethics of individual behavior-Nano-specific issues-practical responses. (10L)

Unit 1I: **Goals of nanotechnology:** Introduction to Societal Implications of Nanoscience and Nanotechnology, Nanotechnology goals**:** Knowledge and scientific understanding of nature, Industrial manufacturing, materials and products, Medicine and the human body (13L)

Unit III: **Nanoparticles and environment:** Nanoparticles in atmospheric environment-Ground water environments and Nanoparticles- Nanoparticles in exhaust gases-Nanoparticles in wastewater. (12L)

Unit 1V: **Safety of nanoparticles:** Problems caused by nanoparticles-Health effects on nanoparticles-Safety assessment for the nanoparticles-Principle of particle removal-Removal of nanoparticles in liquid. (14L)

Unit V: **Purification of Nanomaterials:** Pollution by nanoparticles, Waste remediation: Nanoporous polymers and their applications in water purifications, Photo-catalytic fluid purification. (11L)

Books for Study and Reference

1. Winner, Langdon, "Societal Implications of Nanotechnology", Testimony to---on sciences of the US House of Representatives, 2003
2. Ethics in Engineering, M.Martin & R.Schinzinger, 4th edition, McGraw-Hill [0-07-283115-4];
3. Nanotechnology Regulation and Policy Worldwide (Artech House), Jeffrey H.Matsuura 2006.
4. Vedhanayagam E.G. (1989) Teaching Technology for College Teachers, New Delhi, Sterling Publishers (P) Ltd
5. Rajasekar, S. (2005) Computer Education and Educational Computing, Hyderabad, Neel Kamal Publications

Mapping of Cos to POs and PSOs

CO	Correlation level													Cognitive level
	PO					PSO								
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	M	M	M	M	M	M	M	M	M	M	M	M	M	K1
CO2	M	M	M	M	M	M	M	M	M	M	M	M	M	K2
CO3	M	M	M	M	M	M	M	M	M	M	M	M	M	K3
CO4	M	M	M	M	M	M	M	M	M	M	M	M	M	K4
CO5	M	M	M	M	M	M	M	M	M	M	M	M	M	K5

CARBON NANOSTRUCTURES AND APPLICATIONS

LTPC

3003

CO-1: To introduce the structure and symmetry of carbon nanotubes.

CO-2: Explain the electronic properties of graphene

CO-3: Evaluate the optical properties graphene.

CO-4: Determine the elastic properties of graphene

CO5: Summarise the energy vibrations of graphene

Preamble: This course enables the students to understand the structural symmetry of carbonnanotubes. The learners are expected to gain knowledge about various properties of carbon nanotubes, radial breathing mode and induced Dmode.

Unit 1: **Introduction of carbon nanotubes:** Structures and symmetry-Structure of Carbon nanotubes-Experiments- Symmetry of single-walled carbon nanotubes. (7L)

Unit 1I: **Electronic properties:** Graphene- Zone-folding approximation –Electronic density of states- Beyond zone folding-Curvature effects- Nanotube bundles. (9L)

Unit I1I: **Optical properties:** Absorption and emission-Bundles of nanotubes-Excited state carrier dynamics-Electronic transport-Coulomb blockade. (9L)

Unit 1V: **Elastic properties:** Micro mechanical manipulations- Raman scattering- Raman basics and selection rules-Raman measurements at large phonon q-Double resonant Raman scattering. (11L)

Unit V: **Vibrational properties:** Introduction –Radial breathing mode- The defect induced Dmode-Symmetry of the Raman modes-High energy vibrations. (9L)

Books for Study and Reference

1. Carbon Nanotubes by S.Reich, C. Thomsen and J. Maultzsch
2. Carbon Nanotubes:Properties and Applications by M.J.O'Connell
3. Carbon Nanotube by L.Meyyappan
4. Carbon Nanotechnology by L. Dai
5. Nanotubes and Nanowires by C.N.R.Rao and A.Govindaraj
6. Carbon Nanotube Devices Ed. By Chirstofer Hierold

Mapping of Cos to POs and PSOs

CO	Correlation level												Cognitive level
	PO					PSO							
	1	2	3	4	5	1	2	3	4	5	6	7	8	
CO1	M	M	M	M	M	M	M	M	M	M	M	M	M	K1
CO2	M	M	M	M	M	M	M	M	M	M	M	M	M	K2
CO3	M	M	M	M	M	M	M	M	M	M	M	M	M	K3
CO4	M	M	M	M	M	M	M	M	M	M	M	M	M	K4
CO5	M	M	M	M	M	M	M	M	M	M	M	M	M	K5

PROJECT (11+hours, 8 credits)