

Programme Objectives

The Master of Science (Materials Science) Nanotechnology Consists of Following 2 Programme part(s) Two year course:

Sr. No.	Programme part Name	Programme part Abbreviation	Examination Pattern
1.	M.Sc. Part-I	M.Sc.-I	Semester: FS/SS
2.	M.Sc. Part-II	M.Sc.-II	Semester: FS/SS

The Master of Science (Materials Science) Nanotechnology is available in following medium of instruction/s:

- 1. English**

M.Sc. (Materials Science) Nanotechnology

Scheme of Instruction and Examination

FIRST SEMESTER OF M.Sc. I

Course No.	Subject	No. Of Periods/week				Paper	Examination					Total (Marks)
		Le.	Tu.	Pr.	Total		Duration (In hrs.)	Theory (Marks) EA	Theory (Marks) IA	Practical (Marks)	TW & or Viva (Marks)	
APH2120	Materials Science	3	1	-	4	1	3	70	30	-	-	100
APH2121	Physics Of Nanomaterials- 1	3	1	-	4	1	3	70	30	-	-	100
APH2122	Chemistry of Materials	3	1	-	4	1	3	70	30	-	-	100
APH2123	Scientific Computing and Simulation 1	3	1	-	4	1	3	70	30	-	-	100
APH2121 L	Physics Of Nanomaterials Practicals	-	-	6	6	1	3	-	-	50		50
APH2122 L	Chemistry of Materials Practicals	-	-	6	6	1	3	-	-	50		50
	Total	12	4	12	28	6	18	280	120	100		500

*EA= External Assessment, IA= Internal Assessment

SECOND SEMESTER OF M.Sc. I

Course No.	Subject	No. Of Periods/week				Paper	Examination					Total (Marks)
		Le.	Tu.	Pr.	Total		Duration In hrs.	Theory(Marks)EA	Theory(Marks)IA	Practical(Marks)	TW &or Viva(Marks)	
APH2209	Physics Of Nanomaterials-2	3	1	-	4	1	3	70	30	-	-	100
APH2210	Synthesis Of Nanomaterials	3	1	-	4	1	3	70	30	-	-	100
APH2211	Nano biotechnology	3	1	-	4	1	3	70	30	-	-	100
APH2212	Scientific Computing and Simulation 2	3	1	-	4	1	3	70	30	-	-	100
APH2209 L	Physics Of Nanomaterials-2 Practical	-	-	3	3	1	3	-	-	50		50
APH2210 L	Synthesis Of Nanomaterials Practical	-	-	3	3	1	3	-	-	50		50
	Total	12	4	06	22	6	18	280	120	100		500

FIRST SEMESTER OF M.Sc. II

Course No.	Subject	No. Of Periods/week				Paper	Examination					Total (Marks)
		Le.	Tu.	Pr.	Total		Duration In hrs.	Theory(Marks) EA	Theory(Marks) IA	Practical(Marks)	Marks TW & or Viva	
APH2319	Characterization of Nanomaterials	3	1	-	4	1	3	70	30	-	-	100
APH2321	Nanocomposites and Applications	3	1	-	4	1	3	70	30	-	-	100
APH2322	Nanofabrication	3	1	-	4	1	3	70	30	-	-	100
APH2323	Advanced numerical Methods for Nano-fluids	3	1	-	4	1	3	70	30	-	-	100
APH2323 L	Advanced numerical Methods for Nano-fluids Practical	-	-	6	6	1	3	-	-	50		50
APH2320 L	Materials Science Practical	-	-	6	6	1	3	-	-	50		50
	Total	12	4	12	28	6	18	280	120	100		500

SECOND SEMESTER OF M.Sc. II

[illegible]

Bloom's Taxonomy Levels:

1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

Programme Name: M.Sc. (Materials Science) Nanotechnology

Programme Specific Outcome (PSO)

- PSO1 Learn basics of materials science, quantum and statistical mechanics and develop methodology to understand and solve various problems
- PSO2 Basic understanding and application of the physics and principles of instrumentation
- PSO3 Basic understanding and application of the chemistry and principles of instrumentation
- PSO4 Learn mathematical methods and computational techniques used in nano sciences including simulations
- PSO5 Learn about various properties of materials, working of advanced instrumentation
- PSO6 Synthesis of nanomaterials using chemical approach
- PSO7 Characterization of nanomaterials using advanced analytical techniques
- PSO8 Synthesis of advanced materials
- PSO9 Hands-on practice of basics and advanced experiments intended for industrial and research applications
- PSO10 Training and exposure to research problems through project dissertation
- PSO11 Chemical bonding, structure and synthetic aspects of inorganic/ organic compounds
- PSO12 Synthesis and properties of liquid crystalline and porous nanomaterials
- PSO13 Concepts of various states of matter and reaction order/ rate with and without catalysts and nano-dimension materials

Syllabus of Courses

 सत्यं शिवं सुन्दरम्	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year		2019-20						
<u>.Sc. (Materials Science) Nanotechnology: Regular Programme</u>										
Year	I	Core / Elective / Foundation APH2120: Materials Science	Credits / Hours per week				04			
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade				100			
Mode of Transaction		Lectures and Tutorials								
Course Outcome (CO) APH2120 CO1 Understanding of Engineering Materials CO2 Understanding of crystallography CO3 Understanding the properties of materials CO4 Understanding the types of nanomaterials CO5 Understanding the specific materials										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Introduction of Engineering materials: Metallic materials, Ceramic materials, Polymer, Composite and Nano materials		04	07	1,2	CO1	PSO1			

2	Crystallography: Crystal structure, Atomic structure and; structure of crystalline solids; Lattice unit cells; Crystal systems, Bravais lattices; Indexing of direction and planes, notations, Inter-planar spacing and angles, co-ordination number, packing factors, stacking sequence in BCC, FCC and HCP	09	15	1,2,3,4	CO2	PSO1	SD	G	PE
3	Mechanical Properties of materials: Concept of stress and strain, Stress – strain diagram, properties obtained from the tensile test, Elastic deformation, Plastic deformation, Impact testing & toughness behaviour, Hardness of materials	09	15	1,2,3,4	CO3	PSO1			
4	Phase diagram: Gibbs phase rules, Binary phase diagram and its types, Solid solution – Hume rothery rules. Imperfection: Point defects, Line defects and surface defects – grain boundary, tilt and twin boundary, Grain, Grain size number, Burger vector and its representations	08	13	1,2,4	CO3	PSO1			
5	Ceramic and Polymeric materials: Introduction, ceramic structure, processing of ceramics, properties, glasses; Types of polymerization like addition, condensation and co-polymerization, Ageing Vulcanization cross-linking and branching.	09	15	1,2,3,6	CO3	PSO1			
6	Classification of Materials: Insulators, Semiconductor and conductor on the basis of energy band theory, Fermi Energy, Magnetic Materials, Hard and soft magnetic material	08	13	1,2,4	CO4, CO5	PSO1			
7	Nanomaterials: Definition and introduction to nanomaterials and nanotechnology. Classification of Nanomaterials, Types of Nanomaterials with suitable examples, Applications of nanomaterials as structural, magnetic, electronic and energy related applications	09	15	2,3,5,6	CO4, CO5	PSO1			
8	Composite and other materials: PMC, CMC, MMC, Metallic glasses, superconductors, Type-I and Type-II superconductors, Optic Fibre and Numerical Aperture, corrosion	04	07	1,2,,4,6	CO5	PSO1			
Reference Books									
1.	Askeland D. R., & P.P. Fullay (2007), The science and engineering of materials – 4th Cengage Learning Publishers 45								
2.	William D. Callister, Jr (2008), Callister's Materials science and Engineering, (Adopted by R. Balasubramaniam) Wiley- Estern								
3.	A.S. Edelstein and R.C. Cammarata Ed. (1998), Nano materials: Synthesis, Applications and properties, Inst. Of physics publis hing, UK								
4.	Raghavan V (2007), Material science and Engineering – A first course, Prentice hall, India								
5.	James F. Shackeford (1996), Introductions to materials science for Engineers, Prentice Hall, India								
6.	V.Rajendran, Materials Science, Tata McGraw-Hill Publishing Co. Ltd								

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year			2019-20		
<u>Sc. (Materials Science) Nanotechnology: Regular Programme</u>									
Year	I	Core / Elective / Foundation APH2121: Physics of Nanomaterials-1			Credits / Hours per week			04	
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2016			Maximum Marks / Grade			100	
Mode of Transaction		Lectures							
Course Outcome (CO) APH2121 CO1 Learning the fundamentals of quantum mechanics CO2 Understanding of Nano structures CO3 Applications of quantum mechanics for nanostructures CO4 Understanding of fundamentals of molecular physics, molecular spectrum CO5 Understanding, fabrication and applications of nanotubes CO6 Understanding of Band theory CO7 Understanding of semiconductor physics									
Unit No.	Topic			Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD) Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G) Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	Scales in nanophysics, Quantum structure: 3D-potential wells (spherical & rectangular parallelepiped), 2D circular & square, quantum corrals), 1D (quantum wires), 0D (quantum dots).	06	12	2,3,4	CO1,C O2	PSO1	EMP,SD	G	ES
2	Working Principle of Tunneling Electron Microscope, Atomic Force Microscope, Scanning Tunneling Microscope.	06	12	2,3,5	CO2	PSO1,P SO2			
3	Barrier penetration: Step potential; Rectangular Barrier penetration; Tunneling; WKB. Applications of Barrier penetration.	06	12	2,3,5	CO1,C O3	PSO2			
4	The Harmonic Oscillator: Schrodinger approach; Dirac's bra-k notation & operator algebra; lattice vibrations; phonons. Hydrogen atoms: spherically symmetric potential; spherical harmonics; wave function; orbitals.	10	14	2,3,4	CO1,C O2,CO 3	PSO1,P SO2			
5	Molecular Physics: H ₂ ion, bonds (ionic, covalent, hydrogen) molecular spectrum rotational & vibration levels, Raman spectrum, sigma & pi bonds.	8	13	1,2,4	CO4	PSO3			
6	Carbon nanotubes; Fabrication, Structure, Properties, Applications of CNT, Graphene, Fullerene	7	12	2,3,6	CO2, CO5	PSO4			
7	Energy Bands, Fermi-Dirac statistics, Kronig-Penny model, holes, effective mass, Density of States, 3D, 2D, 1D.	7	12	2,3,4	CO3, CO6	PSO2			
8	Conduction & valence bands, semiconductor physics, intrinsic extrinsic, donor & acceptor levels, charge neutrality, drift & diffusion, transport phenomenon. MOSFET, CMOS	7	13	2,3,4	CO7	PSO2			

Reference Books

1. Nano: The Essentials: Understanding Nanoscience and Nanotechnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
2. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.
3. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, 2nd Edition, Springer
4. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, Tata McGraw Hill,
5. Quantum Mechanics, G. Aruldas, Prentice Hall of India.
6. Introduction to Quantum Mechanics, David J.Griffiths, Pearson Prentice Hall, New Delhi.
7. Introduction to Solid State physics, C. Kittel,8th Edition, Wiley Eastern Ltd.
8. Solid State Physics, C. M. Kachhawa, Tata McGraw Hill.
9. Materials Science, V Rajendran, Tata McGraw Hill.
10. Fundamental of Molecular Spectroscopy, 4th edition, C. N. Banwell& E. M. McCash, Tata McGraw Hill.
11. Physics of Semiconductor Devices, S. M. Sze, Wiley Eastern Ltd.

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics			Academic Year	2019-20	
<u>.Sc. (Materials Science) Nanotechnology: Regular Programme</u>						
Year	I	Core / Elective / Foundation APH2121L : Laboratory Practical	Credits / Hours per week		06	
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade		50	
Mode of Transaction		Laboratory Experiments, discussion and viva	PSO5 is common for all experiments			
Course Outcome (CO) APH2121L CO1Learn basics of classical, quantum and statistical mechanics and develop methodology to understand and solve various problems CO2 Basic understanding and application of the electromagnetic theory, modern optics, laser, crystal physics CO3Semiconductor devices, electronics and their applications CO4 Understanding polarization mechanism, magnetization mechanism						
No.	Experiment		Course Code	BT Level	CO	PSO
1	Dielectric Constant of materials		APH2116L	1,2,3	CO1,CO2	PSO1,PSO2,PSO3
2	ESR		APH2116L	2,3,4	CO2, CO3	PSO2,PSO3
3	Hall Effect		APH2116L	2,3,4	CO2, CO3	PSO1, PSO2,PSO3
4	XRD		APH2116L	2,3,4,5	CO2, CO3	PSO4,
5	Statistical Analysis		APH2116L	4,5	CO1	PSO1,

Syllabus of Courses

 THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA मन्वं शिवं सुन्दरम्	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year	2019-20						
<u>M.Sc. (Materials Science) Nanotechnology: Regular Programme</u>									
Year	I	Core / Elective / Foundation APH2122: Chemistry of Materials	Credits / Hours per week	04					
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade	100					
Mode of Transaction		Lectures and Tutorials							
Course Outcome (CO) APH2122 CO1 Understanding of methods of chemical bonding in organic compounds together with polyaromatic hydrocarbons synthesis CO2 Understanding of structure, bonding and synthesis of inorganic /organometallic compounds together with zeolites, tetravalent metal salts CO3 Understanding the introduction and classification of liquid crystalline and heterocyclic compounds CO4 Understanding the chemical kinetics and theory of reaction rates together with catalysis by supported metal ion and nano-dimension materials CO5 Understanding the state of matter with special emphasis on bonding in solid state									
Unit No.	Topic	Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	Atomic structure, chemical bonding, molecular orbitals, LCAO method, overlapping of MOs.	07	12	1,2	CO1	PSO11			

2	Aromatic chemistry, polynuclear aromatic hydrocarbons, methods of preparation, physical and chemical properties and pericyclic reactions.	08	13	1,2,	CO1	PSO11	Emp	N	ES
3	Introductions to molecular compounds, double salts, coordination compounds, ligands, chelates, Introduction and classification of metal carbonyls, organometallic compounds.	09	13	1,2,3	CO2	PSO11			
4	Structure, bonding and synthesis of some inorganic materials such as zeolites, tetravalent metal acid salts	06	12	1,2,3,6	CO2	PSO12			
5	Introduction to Liquid crystals, classification and synthesis of liquid crystal such as linear, banana shaped and Y- shaped molecules, applications.	07	12	1,2,3,6	CO3	PSO12			
6	Introduction of heterocyclic compounds, classification, numbering, nomenclature, 5- & 6-membered heterocyclic compounds with one or more hetero-atoms.	08	13	1,2	CO3	PSO11			
7	Chemical kinetics, zero, 1st, 2nd order reaction, theories of reaction rates, catalysis, catalysis by supported metal ion, influence of nano-dimensions on catalyst function.	08	13	1,2,3	CO4	PSO13			
8	State of matter: solid, liquid and gas, colloidal state, micelles, solid state, bonding in solid state.	07	12	1,2,5	CO5	PSO13			
Reference Books									
1.	Solid State Chemistry- An Introduction, 4th Edition by Lesley E. Smart, Elaine A. Moore, CRC Press, Taylor & Francis Group, New York.								
2.	Inorganic Chemistry, 5th Edition by Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong, Oxford University Press.								
3.	Organometallic Compounds- A Unified Approach by R C Mehrotra & A. Singh, New Age International Pub.								
4.	Principles of Physical Chemistry, Puri, Sharma and Pathania, Vishal Publishing CO.								
5.	Organic Chemistry, 7 th Edn, Morrison Boyd & Bhattacharjee, Pearson								
6.	Zeolites and Catalysis: Synthesis, Reactions and Applications, Avelino Corma Canos, J. Čejka, Wiley-VCH								

Syllabus of Courses

 मन्वं शिवं सुन्दरम्	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year		2019-20						
<u>M.Sc. (Materials Science) Nanotechnology: Regular Programme</u>										
Year	I	Core / Elective / Foundation APH2122L: Chemistry of Materials- Practical	Credits / Hours per week				06			
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade				50			
Mode of Transaction		Lectures and Tutorials								
Course Outcome (CO) APH2122L CO1 To carry out various organic transformations on lab-scale in context of nanomaterials. CO2 To understand synthesis of various precursors related to important organic materials. CO3 To understand the practical aspects in context to estimation of Inorganic ions/materials. CO4 To understand about various chemical titrations.										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	Advanced Organic Preparations 1. To prepare Neroline from beta Naphthol. 2. To prepare di-benzal acetone from Benzaldehyde.		30	33	2,4	CO1 CO2	PSO8			

	3. To prepare Aspirin from Salicylic acid and Acetic anhydride. 4. To prepare Methyl orange from Sulphonilic acid. 5. To prepare p-nitro acetanilide from Acetanilide.						Emp	N	ES
2	Advanced Inorganic Preparation 1. Preparation of Ferrous Ammonium Sulphate. 2. Preparation of Tris-ethylene diammine Ni (II) sulphate. 3. Preparation of Tetra ammine cupric sulphate. 4. Preparation of lead chromate.	20	23	2,4	CO3	PSO8			
3	Complexometric Titration 1. To determine amount of zinc ions and zinc sulphate in the given solution using 0.01M EDTA solution by Complexometric Titration. 2. To determine amount of calcium ion and magnesium ion in the given solution using 0.01M EDTA solution by Complexometric Titration.	20	22	2,4,5	CO3	PSO9			
4	Redox Titrations 1. To investigate reactions between potassium persulphate and potassium iodide and calculate the rate constant. 2. To investigate the hydrolysis of ester in the presence of acid and calculate the energy of activation.	20	22	2,4,5	CO4	PSO9			

Reference Books

1.	Advanced Practical Organic Chemistry by Vishnoi N. K. (3 rd edition, Vikas Publishing House Pvt. Ltd.) 2009.
2.	Vogel's Textbook of Practical Organic Chemistry-B.S. Furniss, A.J. Hannaford, P.W.J. Smith, A.R. Tatchell (5 th edition, Longman Scientific & Technical) 2005.
3.	Vogel's Textbook of Quantitative Chemical Analysis -J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, (6 th edition, Prentice Hall) 2000.
4.	Advanced Inorganic Analysis- S. K. Agarwal and Keemtilal (11 th Edition, Pragati Prakashan) 2011.
5.	Laboratory Manual of Inorganic Preparations- H.T. Vulte, 2007.
6.	Vogel's Textbook of Quantitative Chemical Analysis -J. Mendham, R. C. Denney, J. D. Barnes and M. J. K. Thomas, (6 th edition, Prentice Hall) 2000.
7.	Advanced Physical Chemistry Experiments, A. Gurtu, J.N. Gurtu (Pragati Prakashan) 2014.
8.	Experiments in Physical Chemistry, J. M. Wilson R. J. Newcombe A. R. Denaro (2 nd edition, Pergamon) 1968.

Syllabus of Courses

 सत्यं शिवं सुन्दरम्	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year		2019-20					
<u>.Sc.(Materials Science) Nanotechnology: Regular Programme</u>										
Year	I	Core / Elective / Foundation APH2123:Numerical Methods and Scientific Computing	Credits / Hours per week				04			
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2019	Maximum Marks / Grade				100			
Mode of Transaction		Lectures and Programming Laboratory								
Course Outcome (CO) APH2123 CO1 Understanding the basics of numerical mathematical methods CO2 Basic Applications of numerical methods and mathematical modelling of simple problems CO3 Programming using GNU Octave CO4 Writing codes to implement the numerical methods										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employa bility (Emp)/ Entrepre neurship (Ent)/ Skill Develop ment (SD)	Relevan ce to Local (L)/ National (N)/ Regional (R)/Glob al (G)	Relation to Gender (G), Environ ment and Sustaina bility (ES), Human Values (HV)and Professio nal Ethics (PE)
1	Unit 1:Errors in numerical calculations: Numbers and their accuracy, Errors and their analysis(absolute, relative and percentage errors), General error formula, Error in a series approximation, error		05	08	2,3,4	CO1 CO2	PSO4			

	propagation						SD	G	PE
2	Unit 2: Solution of algebraic and transcendental equations: Bisection method, method of false position, Newton-Raphson method, Solution of systems of nonlinear equations using Newton-Raphson method	06	08	2,3,4,5	CO1 CO2	PSO4			
3	Unit 3: Interpolation: Errors in polynomial interpolation, finite differences (forward, backward, central), Detection of errors by use of difference tables, Differences of a polynomial, Newton's formula for interpolation (including general formula using divided differences). Gauss's central difference formula	06	12	2,3,4,5	CO1 CO2	PSO4			
4	Unit 4: Differentiation and Integration: Numerical differentiation using cubic spline method, Methods for numerical integration: trapezoidal rule, Simpson's 1/3rd and 3/8th rules	07	14	2,3,4,5	CO1 CO2	PSO4			
5	Unit 5: Curve-fitting: Method of least squares (linear and non-linear), Cubic splines	06	08	2,3,4,5	CO1 CO2	PSO4			
6	Unit 6: Basic features of GNU Octave: Variables, comments, punctuations GNU Octaveworkspace, simple math, complex numbers, mathematical function, operation on vectors and matrices, Logical arrays.	12	15	2,3,4	CO3 CO4	PSO4			
7	Unit 7: Script M-files and function M files, Inline function in GNU Octave; control structure: For loops, While loops, If-else end, Switch-case statements	06	15	2,3,4	CO3 CO4	PSO4			
8	Unit 8: Numerical Linear Algebra: system of linear equations, matrix function, sparse and special matrices Polynomials: Roots, Operations on polynomials. 2D and 3D graphics. ODE and PDE solvers, Optimization tools in GNU Octave	12	20	2,3,4,5	CO3 CO5	PSO4			
Reference Books									
1.	Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India								
2.	Computer Oriented Numerical Methods, V. Rajaraman, Prentice Hall of India.								
3.	Numerical Mathematical Analysis, J. B. Scarborough, Oxford University Press.								
4.	Programming with Computations – MATLAB/Octave, Svein Linge Hans Petter Langtangen, SpringerOpen								

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year						2019-20	
M.Sc. (Materials Science) Nanotechnology: Regular Programme										
Year	I	Core / Elective / Foundation APH2209: Physics of Nanomaterials-2	Credits / Hours per week						04	
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision:2016	Maximum Marks / Grade						100	
Mode of Transaction		Lectures								
Course Outcome (CO) APH2209 CO1 Learning the fundamentals of quantum mechanics CO2 Understanding various methods for analysis of Nano structures CO3construction of solid-state Nano structures CO4 Understanding polarization mechanism CO5Understanding magnetization and superconductivity CO6 Characterization of nanomaterials using advanced analytical techniques										
Unit No.	Topic	Contact Hours	Weightag (%)	BT Level	CO	PSO	Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics(P E)	

1	Quantum Transitions, Time-dependent perturbation theory, Fermi Golden rule, Einstein's A and B coefficients, Transition in quantum structures.	08	15	2,3,4	CO1,C O2	PSO1,P SO2	EMP,SD	G	PE
2	Electron Fundamentals lengths in Solids, Quantum and Classical regimes of electron transport, Landauer formula, Transport in nanostructures, Boltzmann Transport Eqn.	08	15	2,3,4	CO2	PSO1,P SO2			
3	Scattering: Rutherford scattering, Raman scattering, Rutherford backscattering(RBS), medium energy ion scattering(MEIS), low energy electron diffraction(LEED) and reflection high energy electron diffraction(RHEED)	07	10	2,3,5	CO1,C O3	PSO2,P SO4			
4	Quantum structures as optical devices-LASER, LED's, Solar cell	07	10	2,3,5,6	CO1,C O2,CO 3	PSO1,P SO4			
5	Principals of Nano-Semiconductor Devices:2D electron gas system in MOS Inversion layer; Hall effect (Classical, Quantum and fractional) HEMT; SET; Superlattices; Coulomb Blockade.	6	10	2,3,5,6	CO2,C O3	PSO2,P SO4			
6	Polarization mechanism in dielectrics, Clausis-Masotti equation, Dielectric losses and relaxation time, Dielectric breakdown, Measurement of dielectric constant, piezoelectric effect, Ferroelectrics, their classification, Ferroelectric Domains, Theories of Ferro-electricity.	8	13	2,3,4	CO4	PSO5			
7	Magnetism and Superconductivity Magnetism (Paramagnetism, ferromagnetism, ferrofluids, nanomagnetism, giant and colossal magnetoresistance), and Superconductivity (flux quantization, Josephson junction, SQUIDS).	7	12	2,3,4	CO5	PSO6			
8	Characterization: UHV methods, UV and X-ray photoelectron spectroscopy (UPS, XPS) Auger electron spectroscopy(AES), Nanoscale I-V/C-V, Kelvin probe measurements, Deep level transient spectroscopy(DLTS), Cathodluminescence (CL) and luminescence(PL), Electron energy loss spectroscopy (EELS) high resolution EELS(HREELS), low temperature and low noi characterization.	9	15	2,3,4,5,6	CO2,C O6	PSO2,P SO7			
Reference Books									

1. Nano: The Essentials: Understanding Nanoscience and Nanotechnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
2. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.
3. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, 2nd Edition, Springer
4. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, Tata McGraw Hill,
5. Quantum Mechanics, G. Aruldas, Prentice Hall of India.
6. Quantum Hetrostructures, V. V. Mitin, V. A. Kochelap, M. A. Strosio, Cambrige Univ. Press.
7. Introduction to Quantum Mechanics, David J. Griffiths, Pearson Prentice Hall, New Delhi.
8. Introduction to Solid State physics, C. Kittel, 8th Edition, Wiley Eastern Ltd.
9. Solid State Physics, C. M. Kachhawa, Tata McGraw Hill.
10. Materials Science, V Rajendran, Tata McGraw Hill.
11. Fundamental of Molecular Spectroscopy, 4th edition, C. N. Banwell & E. M. McCash, Tata McGraw Hill.
12. Physics of Semiconductor Devices, S. M. Sze, Wiley Eastern Ltd.
13. Fundamental of Solid State Physics, Saxena, Gupta & Saxena, Pragatiprakashan.

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics			Academic Year	2019-20
<u>.Sc. (Materials Science) Nanotechnology: Regular Programme</u>					
Year	I	Core / Elective / Foundation APH2209L : Laboratory Practical	Credits / Hours per week		03
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade		50
Mode of Transaction		Laboratory Experiments, discussion and viva	PSO5 is common for all experiments		
Course Outcome (CO) APH2209L CO1Basic understanding and application of the electromagnetic theory, modern optics, laser, condense matter physics CO2Semiconductor devices, electronics and their applications CO3 Understanding polarization mechanism, magnetization mechanism					
No.	Experiment		Course Code	BT Level	CO PSO
1	Laser		APH2209L	1,2,3	CO1,CO2 PSO1,PSO2,PSO3
2	Solar cell		APH2209L	1,2,	CO2, CO3 PSO2,PSO3
3	Susceptibility		APH2209L	1, 3	CO1, CO3 PSO1, PSO2,PSO3
4	Filter Circuits		APH2209L	1,2	CO2 PSO4,
5	Four Probe		APH2209L	1,2,3	CO1,CO2 PSO1,PSO2,PSO3

Syllabus of Courses

 सत्यं शिवं सुन्दरम्	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year	2019-20							
<u>M.Sc. (Materials Science) Nanotechnology: Regular Programme</u>										
Year	I	Core / Elective / Foundation APH2210: Synthesis of Nanomaterials	Credits / Hours per week					04		
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade					100		
Mode of Transaction		Lectures and Tutorials								
Course Outcome (CO) APH2117 CO1 Understanding of various nano metric forms and their classification CO2 Understanding of techniques of nanomaterial synthesis CO3 Understanding the application of principles of green chemistry CO4 Understanding the nano lithography and self assemble routes CO5 Understanding the specific synthesis processes with special reference of stabilizing agents										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	Introduction to various nanometric forms namely atoms,molecules,nanoclusters, nanopowders,thin films and		07	12	1,2	CO1	PSO11			

	coatings,multi layers,carbon nanotubes,nanowires and nano fibers,nanocrystals,nanocapsules,fullerenes,quantum dots,quantum wires,and nanoporous materials etc.						Emp	N	ES
2	Classifications and types of nanomaterials as nanoparticles and 1D 2D 3D nanomaterials.Concept of bulk versus nanomaterials and dependence of properties on size.	08	13	1,2,	CO1	PSO11			
3	Classifications of techniques of nanosynthesis, Top down vs Bottom up approach of synthesis with examples.Nanosynthesis techniques based on vapour phase as the starting material.The study of techniques such as inert gas condensation,physical vapour deposition,sputtering, plasma deposition process,chemical vapour depositionetc. with examples.	09	13	1,2,3	CO3	PSO11			
4	Brule force methods vs soft Chemistry routes,sol-gel method,microemulsion technique, reduction of metal salts,decomposition of organometallic precursors,cryochemical synthesis etc.Study of rapid solidification route,electro and electroless deposition etc. along with examples.	06	12	1,2,3,6	CO3	PSO12			
5	Application of the Principles of Green Chemistry to nano science, citrate gel method, CFC(controlled flow cavitation),SCF's(super critical fluids), microwave and ultrasound assisted synthesis.	07	12	1,2,3,6	CO4	PSO12			
6	Synthesis of 3D nanostructured materials using high-energy mechanical attrition by devitrification of an amorphous precursors,etc.Introduction to nanolithography and self-assembly routes.	08	13	1,2	CO4	PSO11			
7	Introduction to specific synthesis processes like synthesis of semiconductor nanoparticles in colloidal solution,preparation of quantum dots,nanowires and films,preparation of single-walled and multi-walled nanotubes.	08	13	1,2,3	CO5	PSO13			
8	Introduction to specific nanoparticles synthesis: in colloidal solutions,Surfactants,physical chemistry or surfactant behaviour,micelles,self assembly,self assembled	07	12	1,2,5	CO5	PSO13			

	monolayers.(SAM's),Langmuir-Blodgett(LB)films,organic block copolymers,emulsions.								
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Reference Books

1. Nanomaterials synthesis, properties and applications, ed. A. S. Edelstein and R. C. Cammarata, published by Institute of Physics, UK, 1996.
2. Handbook of Nanophase and nanostructured materials, ed. Z. L. Wang, Z. Zhang and Y. Lim, Kluwer Academic publisher, 2002.
3. Recent Advances in the Liquid-Phase Syntheses of Inorganic Nanoparticles, Chem. Rev. 2004, 104, 3893-3946.
4. Toward Greener Nanosynthesis, Chem. Rev. 2007, 107, 2228-2269.
5. Surfactants and Interfacial Phenomena, 4thed, M. J. Rosen and J. T. Kunjappu, WILEY, 2012.

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year	2019-20							
<u>M.Sc. (Materials Science) Nanotechnology: Regular Programme</u>										
Year	I	Core / Elective / Foundation APH2210L: Synthesis of Nanomaterials-Practical	Credits / Hours per week							03
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade							50
Mode of Transaction		Lectures and Tutorials								
Course Outcome (CO) APH2210L CO1 To determine critical micelle concentration of ionic surfactants. CO2 To synthesize various metallic nanoparticles. CO3 To synthesize graphene oxide/ zirconium oxide nanocomposites. CO4 To prepare nano-emulsion and study various phenomenon of surfactant science.										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	To determine Critical Micelle Concentration of an anionic surfactants.		6	13	2	CO1	PSO9			

2	To determine Critical Micelle Concentration of a cationic surfactants.	6	13	2	CO1	PSO9	Emp	N	ES
3	To synthesize silver nanoparticles using ascorbic acid as a reducing agent.	6	13	3,6	CO2	PSO6			
4	To synthesize gold nanoparticles using hydro auric acid.	6	13	3,6	CO2	PSO6			
5	To synthesize Nano composites of graphene oxide with zirconium oxide.	6	13	3,6	CO3	PSO6			
6	To prepare Nano emulsion using various components such as surfactants, oil, water and co-surfactants.	3	9	2,4	CO4	PSO6			
7	To prepare cloud curve using a non-ionic surfactants.	6	13	2,4	CO4	PSO9			
8	To synthesize zinc sulphide nanoparticles using sol-gel method.	6	13	3,6	CO2	PSO6			
Reference Books									
1.	Advanced Practical Organic Chemistry by Vishnoi N. K. (3 rd edition, Vikas Publishing House Pvt. Ltd.) 2009.								
2.	Surfactants and Interfacial Phenomena, Fourth Edition, M. J. Rosen and J. T. Kunjappu, Wiley 2012.								
3.	Elements of Physical Chemistry, Puri, Sharma and Pathania								

Syllabus of Courses

 सत्यं शिवं सुन्दरम्	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year			2019-20				
<u>.Sc. (Materials Science) Nanotechnology: Regular Programme</u>										
Year	I	Core / Elective / Foundation APH2211: NANO BIOTECHNOLOGY	Credits / Hours per week			04				
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade			100				
Mode of Transaction		Lectures and Tutorials								
Course Outcome (CO) APH2211 CO1 Understanding of nano microscopes CO2 Understanding of nano lithography CO3 Understanding the quantum dots CO4 Understanding the nano fluidics and Raman spectroscopy CO5 Understanding the Molecular and cellular biology CO6 Understanding the Drug Delivery CO7 Understanding the specific nano particles CO8 Understanding the Toxicity										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)

1	Unit I: Fundamentals of Nano-enabled drug Discovery tools: Atomic force microscopy (AFM) and the Congruent force intermolecular test, Field-ion microscope, Near-field Scanning Optical Microscope (SNOM or NSOM)	04	07	2,3,4	CO1	PSO5 PSO7	SD	G	PE
2	Unit II: Surface Plasma Resonance (SPR), Nano-Mass spectroscopy, Dip-Pen Nanolithography (DPN)	09	15	2,3,4	CO2	PSO5 PSO7			
3	Unit III: Nanoparticles for Drug Discovery, Quantum Dots and Gold Nanoparticles for High-Content and initial Drug Screening	09	15	3,4,5	CO3	PSO5 PSO7			
4	Unit IV: Microarrays and Nanoarrays, Microfluidics and Nanofluidics, Nanoshells for Raman Spectroscopy, Nanobarcode particles	08	13	2,3,4	CO4	PSO5 PSO7			
5	Unit V: Introduction, definition and classification: Molecular and cellular biology basis of in Drug Discovery and Development, Application of Nanotechnology in Drug Discovery	09	15	2,3,4	CO5	PSO5 PSO7			
6	Unit VI: Nanomaterial Drugs, Abraxane, RenaZorb, Antimicrobial, Emulsion, Antioxidant and Anti-HIV Fullerenes. Nanotechnology in Drug Delivery, Nanoparticles: Definitoins, Classifications	08	13	2,3,4	CO6	PSO5 PSO7			
7	Unit VII: Polymeric nanoparticles: Types, synthesis, purification, characterization, property, biodegradation Liquid, nanoparticles: Types, preparation, purification, characterization, properties, bio-degradation	09	15	2,3,4	CO7	PSO5 PSO7			
8	Unit VIII: Hydrogel nanoparticles: Synthesis, properties, Peptide nanoparticles: Toxicity and toxicity evaluation of nanoparticles	04	07	2,3,4,6	CO8	PSO5 PSO7			

Reference Books

1.	Introduction to Nanotechnology by Poole Jr and Owens, Wiley Interscience
2.	Nano: The Essentials by T. Pradeep, Tata McGraw-Hill Publishing Co. Ltd, New Delhi
3.	Nanotechnology: Principles and Practices by Sulbha K. Kulkarni, Capital Publishing Co, New Delhi
4.	Nanotechnology: Basic Calculations for Engineers and Scientists, Wiley Interscience, Louis Theodore

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year		2019-20					
<u>.Sc.(Materials Science) Nanotechnology: Regular Programme</u>										
Year	I	Core / Elective / Foundation APH2216:Mathematical Methods for Scientific Computing	Credits / Hours per week				04			
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision: 2019	Maximum Marks / Grade				100			
Mode of Transaction		Lectures and Programming Laboratory								
Course Outcome (CO) APH2216 CO1 Learn some advanced numerical mathematical methods CO2 Applications of numerical methods and mathematical modelling of general problems CO3 Implementation of the methods using GNU Octave CO4 Developing set of codes to implement the numerical methods used in materials science										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employa bility (Emp)/ Entrepre neurship (Ent)/ Skill Develop ment (SD)	Relevan ce to Local (L)/ National (N)/ Regional (R)/Glob al (G)	Relation to Gender (G), Environ ment and Sustaina bility (ES), Human Values (HV)and Professio nal Ethics (PE)
1	Unit 1:Numerical solution of ordinary differential equations: Solution by Taylor Series, Picard’s Method of successive approximations, Euler’s method, Runge-Kutta methods		05	08	2,3,4,5	CO1 CO2 CO3 CO4	PSO4			

2	Unit 2: Numerical solution of partial differential equations: Finite difference approximations to derivatives, Solution of Laplace's equation using Jacobi, Gauss-Seidel and Successive over-relaxation methods, parabolic equations, Iterative methods.	06	08	2,3,4,5	CO1 CO2 CO3 CO4	PSO4	SD	G	PE
3	Unit 3: Random numbers and Monte Carlo integration: Random variables, probability density and Cumulative probability distribution function, Random numbers, Random number generators (RNG), Properties of good RNG, Linear congruential generator, Lagged Fibonacci generators, Shift register generators, hit and miss method, Random numbers with given distribution (exponential, Gaussian), Monte Carlo integration (one and multi-dimensional), sample-mean method.	06	12	2,3,4,5	CO1 CO2 CO3 CO4	PSO4			
4	Unit 4: Integral transforms: Development of Fourier integral, Fourier transform, inversion theorem, Fourier transform of derivatives, Discrete Fourier Transform, convolution theorems and applications. Elementary Laplace's transform, Laplace's transform of derivatives, other properties, convolution theorems, inverse Laplace's transform, applications.	07	14	2,3,4,5	CO1 CO2 CO3 CO4	PSO4			
5	Unit 5: Complex Analysis: Complex numbers, Complex functions (polynomials, Exponential, Trigonometric complex functions, Logarithm). Limits and continuity, differentiation, Analytical functions, Cauchy-Riemann conditions, Cauchy's theorem, Cauchy integral formula, Laurent's theorem. Calculus of residues, Evaluation of real definite integrals	06	08	2,3,4,5	CO1 CO2 CO3 CO4	PSO4			
6	Unit 6: Matrices and Linear systems of equations: Matrix operations, consistency of linear system of equations, vector and matrix norms, solution of linear systems using Matrix inversion and Gauss elimination and iterative methods, the eigenvalue problem	12	15	2,3,4,5	CO1 CO2 CO3 CO4	PSO4			

Reference Books

1.	Mathematical Methods for Physicists, Arfken and Weber, Academic Press.
2.	Mathematical Methods in Physical Sciences, M. L. Boas, Wiley
3.	Complex Variables and Applications, R. V. Churchill, McGraw Hill
4.	Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall of India
5.	Computer Oriented Numerical Methods, V. Rajaraman, Prentice Hall of India.
6.	Numerical Mathematical Analysis, J. B. Scarborough, Oxford University Press.
7.	Computational Physics: Simulation of classical & quantum systems, P. O. J. Scherer, Springer.

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year		2020-21						
<u>.Sc. (Materials Science) Nanotechnology: Regular Programme</u>										
Year	II	Core / Elective / Foundation APH2319: Characterization of Nanomaterials	Credits / Hours per week				04			
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade				100			
Mode of Transaction		Lectures and Tutorials								
Course Outcome (CO) APH2319 CO1 Understanding of nanoscience CO2 Understanding of nanostructure CO3 Understanding the characterization techniques CO4 Understanding the advanced instrumentation CO5 Understanding the thermal characterization										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Unit 1: Particle size, surface area and volume calculations, Increase in		04	07	2,3,4	CO1	PSO2			

Reference Books	
1.	Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
2.	W. Callister, Fundamentals of Materials Science
3.	Elements of X –ray Diffraction, B. D. Cullity
4.	Physical Principles of Electron Microscopy: An Intro.to TEM, SEM, and AEM Ray F. Egerton
5.	Thermal Analysis of Materials, Robert F Speyer, New York.
6.	Introduction to Nanotechnology by Poole Jr and Owens, Wiley Interscience
7.	Nano: The Essentials by T. Pradeep, Tata McGraw-Hill Publishing Co. Ltd, New Delhi
8.	Nanotechnology: Principles and Practices by Sulbha K. Kulkarni, Capital Publishing Co, New Delhi
9.	Handbook of Nanotechnology, Bharat Bhushan
10.	Nanoscience and Nanotechnology, H.S. Nalwa
11.	Spectrometric Identification of Organic Compounds, Wiley, R.M. Silverstein and F.X. Webster
12.	Fundamentals of Molecular Spectroscopy, TMH, C.N.Banwell and E.M.McCash
13.	Nanotechnology: Basic Calculations for Engineers and Scientists, Wiley Interscience, Louis Theodore

Syllabus of Courses

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year		2020-21					
M.Sc. (Materials Science) Nanotechnology : Regular Programme											
Year	II	Core / Elective / Foundation APH2320L : Laboratory Practical/TW			Credits / Hours per week		03				
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2016			Maximum Marks / Grade		50				
Mode of Transaction		Laboratory Experiments, TW			PSO7 is common for all experiments						
No.	CO 1 : Understanding of Instruments CO2 : Working of Characterizing Tools Experiment				Course Code	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	X –Ray Diffraction				APH2102	1,2	CO1	PSO1	SD	G	PE
2	Surface Probe Microscopy				APH2203	2	CO2	PSO2			
3	Atomic Force Microscopy				APH2102	2,3	CO1	PSO1, PSO2			
4	Infrared Spectroscopy				APH2102	3,4	CO2	PSO4			
5	Fourier Transform Infrared Spectroscopy				APH2102	2,3	CO1	PSO1, PSO4			
6	BET Analysis				APH2201	2,3	CO1	PSO1			

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year	2020-21						
M.Sc. (Materials Science) Nanotechnology: Regular Programme									
Year	II	Core / Elective / Foundation APH2321: Nanocomposites and Applications	Credits / Hours per week	04					
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision:2016	Maximum Marks / Grade	100					
Mode of Transaction		Lectures							
Course Outcome (CO) APH2321 CO1 Learning the fundamentals of Nanocomposites CO2 Understanding various methods for synthesis of Nanocomposites CO3 Understanding various polymer based Nanocomposites CO4 Understanding Mechanical behaviour CO5 Characterization and Applications CO6 Reinforcement									
Unit No.	Topic	Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employa bility (Emp)/ Entrepre neurship (Ent)/ Skill Develop ment (SD)	Relevan ce to Local (L)/ National (N)/ Regional (R)/Glob al (G)	Relation to Gender (G), Environ ment and Sustaina bility (ES), Human Values (HV)and Professio nal Ethics(P E)
1	General introduction to composites and nanocomposites, types	08	15	2,3,4	CO1,	PSO1,			

	of composites,fibre composites,fibres,polymer composites,metal matrixComposites, metal nanocluster glassesceramic matrix composites.				CO2	PSO2	EMP,SD	G	PE
2	Nanocomposites by mechanical alloying, amorphous-crystal composites by copper mold casting.	08	15	2,3,4	CO2	PSO1,P SO2			
3	Sol-gel synthesis, thermal spray synthesis, thin film nanocomposites,nanocomposites for optical and electrical application,nanocomposites materials with miscellaneous properties.	07	10	2,3,5	CO1,C O2	PSO2,P SO4			
4	Polymer based and polymer filled nanocomposites,Polyme processes, processing of polymer nanocomposites, nanotubes,nanotube processing polyimide,polyimide, Polyethylene.	07	10	2,3,5,6	CO1,C O2,CO 3	PSO1,P SO4			
5	Polyurethane and polymethylmethacrylate matrices,rubber matrices,epoxy matrix, ceramic and metal filled polymer nanocomposites.	6	10	2,3,5,6	CO2,C O3	PSO2,P SO4			
6	Mechanical behaviour of composite (flexural,compressive,tensile,And dynamic mechanical),Bulk Matallic Glasses and their applications in golf club,Impactstrength,magneticapplications,abrasion and wear resistant composites,lightemmiting devices.	8	13	2,3,4	CO4	PSO5			
7	Nanocomposites: particulate,clay,nanocomposites, Nanocomposites synthesis,characterization, properties and applications.	7	12	2,3,4	CO5	PSO6			
8	Nanomaterial reinforcement in composites, benefits nanotechnology in composite development, Multifunctional composites and candidates for multifunctional composites,Self healing materials.	9	15	2,3,4,5,6	CO2,C O6	PSO2,P SO7			
Reference Books									

1. P. M. Ajayan, L. S. Schadler, P. V. Barun, Nanocomposites Science and Technology, Wiley, 2003.
2. K. K. Chavala, Composite Materials Science and Engineering, 2nd ed New York: Springer, 1998.
3. B. T. Astom, Manufacturing of Polymer composites, London: Chapman and Hall, 1997.
4. D. Hull, Introduction to composites, New York: Cambridge University Press, 1996.
5. M. F. Ashby and L. J. Gibson, Cellular solids: Structure and Properties, 2nd ed. New York: Cambridge University Press, 1997.

Syllabus of Courses

 सत्यं शिवं सुन्दरम्	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year		2020-21					
<u>.Sc.(Materials Science) Nanotechnology: Regular Programme</u>										
Year	II	Core / Elective / Foundation APH2322:Nanofabrication	Credits / Hours per week				04			
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision: 2019	Maximum Marks / Grade				100			
Mode of Transaction		Lectures and Programming Laboratory								
Course Outcome (CO) APH2322 CO1 Understanding the basics nanolithography and learn advanced techniques CO2 Introduction to nanosensors, their fabrication and applications CO3 Learn about various deposition techniques for growing nanostructures CO4 Fundamentals of nanooptics and related applications CO5 Basics and applications of quantum well lasers and other nanostructured devices										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employa bility (Emp)/ Entrepre neurship (Ent)/ Skill Develop ment (SD)	Relevan ce to Local (L)/ National (N)/ Regional (R)/Glob al (G)	Relation to Gender (G), Environ ment and Sustaina bility (ES), Human Values (HV)and Professio nal Ethics (PE)
1	Introduction to Nanolithography,Study of lithographic techniques Based on use of photons viz.UV,LASER and X-ray;Lithography based on use of particle beams viz. electron beam,ion beam and		10	20	2,3,4,5	CO1	PSO8			

	neutrons beam;Advanced techniques in lithography such as Scanning probe,Dip-pen, Thermo-mechanical lithographyetc.Basic principles of soft lithography method.						Emp. SD	N, G	PE
2	Introduction to Nanosensors.Types of Nanosensors,Fabrication of Nanosensors based on quantum size effects,optical and other physical properties,Fabrication based on electrochemical principles ,Recent advances in nanosensors,Nano and Micro Electro Mechanical Systems.	10	15	2,3,4,5	CO2	PSO8			
3	Deposition techniques,Chemical Vapour Deposition,Plasma Enhanced Chemical Vapour Deposition,Pulse LASER deposition,Magnetron and ion beam sputter deposition,Electroplating,Electrochemical techniques,Epitaxial methods for layered structures,Molecular beam epitaxy.	10	15	2,3,4,5	CO3	PSO8			
4	Nano-optics,optical properties of quantum structures,intraband transitions in quantum structures,Nonlinear optics in quantum structures and applications,LED's and LASER's using quantum structures,optical probe techniques.	12	15	2,3,4,5	CO4	PSO8			
5	Angular momentum,orbital and spin angular momenta,transition in bulk semiconductor and its dependence on angular momentum,heavy and light holes,Transport in quantum structures,double barrier resonant tunneling structures,organic semiconductors,molecular electronics.	12	20	2,3,4	CO5	PSO8			
6	Molecular Self-Assembly,pattern formation using selfassembly,folding of polypeptide chains,self assembled monolayers,miscles.	06	15	2,3,4	CO5	PSO8			

Reference Books

1.	Hari Singh Nalwa, Nanoscience and Nanotechnology, Academic Press,2002.
2.	Avery n. Goldstein, Handbook of Nanophase Materials, marcel Dekker, Inc.,1997.
3.	Quantum Heterostructures by Vladimir V. Mitin, et. Al. Cambridge University Press. 1999
4.	Herve Rigneault et. al., Nanophotonics, ISTE, 2006.
5.	V.V.Antsiferov, Physics of Solid State LASERS, Viva Publications, 2008.
6.	Quantum Well Lasers by Peter Zory, Academic Press, 1993

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year	2020-21						
M.Sc.-I (Materials Science) Nanotechnology: Regular Programme									
Year	II	Core / Elective / Foundation APH2323:Computer Simulation Techniques in Materials Science	Credits / Hours per week	04					
Semester	I	Year of Introduction: 2007 Year of Syllabus Revision:2019	Maximum Marks / Grade	100					
Mode of Transaction		Lectures							
Course Outcome (CO) APH2323 CO1 Concepts of Statistical mechanics for computer simulation of materials CO2 Monte Carlo Methods CO3 Applications of Monte Carlo Methods in Simulations CO4 Advanced methods for solving coupled differential equations CO5 Introduction to Electronic structure methods and density functional theory CO6 Basics and applications of classical molecular dynamics									
Unit No.	Topic	Contact Hours	Weightage (%)	BT Level	CO	PSO	Element s of Employa bility (Emp)/ Entrepre neurship (Ent)/ Skill Develop ment (SD)	Relevan ce to Local (L)/ National (N)/ Regional (R)/Glob al (G)	Relation to Gender (G), Environ ment and Sustaina bility (ES), Human Values (HV)and Professio nal Ethics(P E)
1	Numerical solution of differential equations (Advanced):	08	20	2,3,4,5	CO4				

	Solution of coupled/simultaneous ordinary differential equations, higher order differential equations, Numerov Method, solution of Schrodinger equation, finite difference and finite element methods						EMP,SD	G	PE
2	<i>Electronic structure Methods</i> : Quantum mechanics of multi-electron systems, Early density functional theories	06	10	2,3,4,5	CO5	PSO1 PSO4			
3	<i>Electronic structure Methods(Conti)</i> : The Hohenberg-Kohn theorem, Kohn-Sham method, The exchange-correlation functional, Wave functions, Pseudopotentials, Use of density functional theory	06	10	2,3,4,5	CO5	PSO1 PSO4			
4	<i>Basics of statistical mechanics for computer simulation of materials</i> : A brief introduction to phase space and time evolution of a system in phase space, Entropy and temperature, Statistical ensembles (microcanonical, canonical, grand canonical)	10	10	2,3,4	CO1	PSO1,P SO2			
5	<i>Monte Carlo Simulation</i> : Importance Sampling–Weighted Monte Carlo integration, Fundamentals of the Metropolis algorithm, Metropolis method for microcanonical and canonical ensembles	09	15	2,3,4	CO2	PSO1,P SO2			
6	Applications of <i>Monte Carlo Simulation</i> : Random walk, Spin Ising model, A Lennard-Jones system (equation of state)	09	15	2,3,5	CO2C O3	PSO2,P SO4			
7	<i>Classical Molecular Dynamics (MD) Simulation</i> : MD–The idea and algorithm, Interaction potentials for modeling the physical system, Time integration algorithms (the Verlet algorithm, Predictor-Corrector algorithm), Boundary Conditions	06	10	2,3,4,5	CO6	PSO1 PSO4			
8	<i>Classical Molecular Dynamics (MD) Simulation(Conti)</i> : MD–A Program (Running, measuring and analyzing), Starting a simulation, Controlling a system, Equilibration, Measurement of simple statistical quantities(potential energy, kinetic energy, total energy, temperature, pressure) Application: Simulation of static properties of Lennard-Jones fluid	06	10	2,3,4,5	CO6	PSO1 PSO4			
Reference Books									

- (1) Computational Materials Science, D. Raabe, Wiley-VCH
- (2) Understanding Molecular Simulation, D. Frankel and B. Smith, Academic Press.
- (3) Computer Simulation of Liquids, M. P. Allen and D. J. Tildesley, Clarendon Press, Oxford.
- (4) Introduction to Computational Materials Science, Richard Lesar, Cambridge University Press.
- (5) Computational Physics – Problem solving with computers, Landau, Paez and Bordeianu, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim.

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics		Academic Year		2020-21			
<u>.Sc.(Materials Science) Nanotechnology: Regular Programme</u>									
Year		II		Core / Elective / Foundation APH2323L:Computer Simulation Techniques in Materials Science		Credits / Hours per week		03	
Semester		I		Year of Introduction: 2007 Year of Syllabus Revision: 2019		Maximum Marks / Grade		50	
Mode of Transaction			Laboratory Experiments, Simulations, discussion and viva				PSO4 is common for all experiments BT Level is 3,4,5for all experiments		
No.	Experiment								
1	Coding for solution of coupled second order ordinary differential equation								
2	Simulation of damped harmonic oscillator using RK4 method								
3	Predator Prey Model using RK4 method								
4	Spread of contagious disease in closed colony								
5	Solution of second order partial differential equations								
6	Laplace's equation								
7	Poisson's equation								
8	Time dependent heat equation								
9	Numerical Solution of Schrodinger equation for different potentials								

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year		2020-21						
<u>M.Sc. (Materials Science) Nanotechnology: Regular Programme</u>										
Year	II	Core / Elective / Foundation APH2418: Major Project Dissertation	Credits / Hours per week				20			
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade				300			
Mode of Transaction		Lectures and Tutorials								
Course Outcome (CO) APH2418 CO1 Understanding of various Field work CO2 Understanding of techniques of nanomaterial synthesis										
Unit No.	Topic		Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Major Project Dissertation		60	100	1,2,3,4,5,6	CO1 CO2	All PSO1 to PSO13	Emp	N	ES

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Applied Physics	Academic Year	2020-21						
<u>M.Sc. (Materials Science) Nanotechnology: Regular Programme</u>									
Year	II	Core / Elective / Foundation APH2419: Minor Project Dissertation	Credits / Hours per week 04						
Semester	II	Year of Introduction: 2007 Year of Syllabus Revision: 2016	Maximum Marks / Grade 100						
Mode of Transaction		Lectures and Tutorials							
Course Outcome (CO) APH2419 CO1 Understanding of various Field work CO2 Understanding of techniques of nanomaterial synthesis									
Unit No.	Topic	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional (R)/ Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV) and Professional Ethics (PE)
1	Minor Project Dissertation	60	100	1,2,3,4,5,6	CO1 CO2	All PSO1 to PSO13	Emp	N	ES