SHIVAJI UNIVERSITY, KOLHAPUR - 416004,
MAHARASHTRA
PHONE:EPABX-2609000, www.unishivaji.ac.in, bos@unishivaji.ac.in
शिवाजी विद्यापीठ, कोल्हापूर -४१६००४,महाराष्ट्र
दूरध्वनी-ईपीएबीएक्स -२६०९०००, अभ्यासमंडळे विभाग दुरध्वनी ०२३१—२६०९०९४
०२३१—२६०९४८७

Estd. 1962
"A++" Accredited by
NAAC (2021)
With CGPA 3.52

Ref.No.SU/BOS/Science/150 **Date: 26/05/2026.**

The Principal,
All Concerned Affiliated Colleges/Institutions
Shivaji University, Kolhapur

The Head/Co-ordinator/Director
All Concerned Department (Science)
Shivaji University, Kolhapur.

Subject: Regarding revised syllabi of degree programme under the Faculty of Science and Technology as per NEP-2020.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, nature of question paper and equivalence of degree programme under the Faculty of Science and Technology as per NEP-2020.

1.	B.Sc. Part II Medicinal Chemistry (Entire) (2.0)	6.	BCA Part III
2.	B.A./B.A.B.Ed Part III Geography (2.0)	7.	B.Sc. Part II Data Science
3.	B.Sc. Part II Artificial Intelligence	8.	B.Sc.-M.Sc. Part III AI & ML
4.	B.Sc.-M.Sc. Part IV Nano Science and Technology (1.0)	9.	MCA Part II (YCSRD)
5.	B.Sc.-M.Sc. Part III Nano Science and Technology (2.0)	10.	MCA Part II

This syllabus, nature of question and equivalence shall be implemented from the academic year 2026-2027 onwards. A soft copy containing the syllabus is attached herewith and it is also available on university website **www.unishivaji.ac.in>Syllabus>Syllabus as per NEP2020.**

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October /November 2026 & March/April 2027. These chances are available for repeater students, if any.

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dy Registrar

Encl: as above

for information and necessary action

Copy to:

1	Dean, Faculty of Science & Technology	6	Appointment Section A & B
2	Director, Board of Examinations and Evaluation	7	I.T.Cell /Computer Centre
3	Chairman, Respective Board of Studies	8	Eligibility Section
4	B.A.,OE-II & B.Sc.-M.Sc. Exam Section	9	Affiliation Section (T.1) (T.2)
5	Internal Quality Assurance Cell (IQAC Cell)	10	P.G. Seminar Section

Shivaji University, Kolhapur

Accredited by NAAC (2021) 'A++' Grade with CGPA 3.52

NATIONAL EDUCATION POLICY (NEP-2020)

Syllabus for

B. Sc.-M. Sc. in Nanoscience and Technology,

(5 Years Integrated) Program,

Part-IV, (NEP 2.0)

Syllabus to be implemented from the academic year 2026-27

(July 2026) onwards.

Implementation: The implementation gradually as mentioned below –

B.Sc.-M. Sc. in Nanoscience and Technology (5 Years Integrated) Programme

a) B.Sc.-M. Sc. (5 Years Integrated) Part – I from the Academic year 2023-24
b) B.Sc. -M. Sc. (5 Years Integrated) Part – II from the Academic year 2024-25
c) B.Sc. -M. Sc. (5 Years Integrated) Part – III from the Academic year 2025-26
d) **B.Sc. -M. Sc. (5 Years Integrated) Part – IV from the Academic year 2026-27**
e) B.Sc. -M. Sc. (5 Years Integrated) Part – V from the Academic year 2027-28

Programme: B.Sc.-M.Sc. in Nanoscience and Technology (5 Years Integrated) (NST)

Course code Abbreviations

Sr. No.	Name	Short form
1	Major	DMJ/MJ
2	Minor	DMN/MN
3	Generic Elective Course	GEC
4	Interdisciplinary Course	IDC
5	Discipline Course	DSC
6	Open Elective Course	OE
7	Ability Enhancement Course (English)	AECC
8	Indian Knowledge System	IKS
9	Field Projects	FP
10	Community Engagement Practice	CEP
11	Co-Curricular Courses	CC
12	Research Project	RP
13	Value Education Courses ()	VEC
14	Vocational Skill course	VSC
15	Skill Enhancement Courses	SEC
16	Discipline Specific Elective Course	DSE
17	Multidisciplinary	MDC
18	Value Added Course: [(Maths +Biology), Env. Studies]	VAC
19	Major Mandatory	MM
20	Major Elective	ME
21	Research Methodology/ n Job Training	RM/OJT

B.Sc.-M.Sc. in Nanoscience and Technology (5 Years Integrated) (NST)

List of course with the codes

Sr. No.	Name of the Course	Course Code
1	Physics	01
2	Chemistry	02
3	Biotechnology	03
4	Mathematics	04
5	Electronics	05
6	English	06
7	Nanoscience	07
8	Nanoscience and Technology	08
9	Statistics	09
10	Environmental Science	10
11	Biology	11
12	Nanobiotechnology	12

B.Sc.-M.Sc. in Nanoscience and Technology (5 Years Integrated), Part-IV, SEM-VII and SEM-VIII

Sr. No.	Paper Code	Title of the Paper
SEM VII		
1	NSTU0325MML501G1	Semiconductor Physics
2	NSTU0325MML502G1	Carbaneous Materials
3	NSTU0325MML512G1	Fundamental of Nanobiotechnology
4	NSTU0325MML508G1	Coating Technology, Nanocoatings and Applications
5	NSTU0325MEL508G1	Functional Nanomaterials
6	NSTU0325MEL501G1	Quantum Mechanics at Nanoscale
7	NSTU0325RPP501G1	**Laboratory Course – I** (Semiconductor Physics)
8	NSTU0325RPP502G1	**Laboratory Course – II** (Carbaneous Materials)
9	NSTU0325FPP5012G1	**Laboratory Course – III** (Nanobiotechnology)
10	NSTU0325RPP508G1	**Laboratory Course – IV** (Coating Technology, Nanocoatings and Applications + Functional Nanomaterials)
SEM VIII		
11	NSTU0325MML501H1	Solid State Electronic Devices
12	NSTU0325MML502H1	Fundamentals of Nanocatalysis and Applications
13	NSTU0325MML512H1	Biomedical Applications of Nanobiotechnology
14	NSTU0325MML508H1	Energy Conversion and Storage Devices
15	NSTU0325MEL504H1	Nanomagnetism and Spintronics
16	NSTU0325MEL502H1	Statistical Mechanics and Nanothermodynamics
17	NSTU0325RPP501H1	**Laboratory Course – I** (Solid State Electronic Devices)
18	NSTU0325RPP502H1	**Laboratory Course – II** (Fundamentals of Nanocatalysis and Applications)
19	NSTU0325FPP512H1	**Laboratory Course – III** Biomedical Applications of Nanobiotechnology
20	NSTU0325RPP508H1	**Laboratory Course – IV** (Energy Conversion and Storage Devices)

The following shall be the courses of the studies under the NEP-2020 pattern (NEP 2.0)

B. Sc. - M. Sc. in Nanoscience and Technology (5 Years Integrated) - Part-IV, SEM-VII and SEM-VIII

NEP-2020 PATTERN (2026-27)

SEMESTER-VII (Duration – 6 Months)																			
Sr. No.	Course Title	Teaching Scheme						Examination Scheme											
								Theory								Practical			
		Theory			Practical			Theory			Internal			Total		Total			
		No. of lectures	Hours	Credits	No. of Lectures	Hours	Credits	Max.	Min.	Hours	Max.	Min.	Hours	Max.	Min.	Max.	Min.	Hours
1	Semiconductor Physics	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
2	Carbaneous Materials	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
3	Fundamental of Nanobiotechnology	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
4	Coating Technology, Nanocoatings and Applications	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
5	Functional Nanomaterials	4	4	4				80	28	3	20	7	1	100	35			
6	Quantum Mechanics at Nanoscale	2	2	2	-	-	-	40	14	2	10	4	0.5	50	18	-	-	-
	Total	**22**	**22**	**22**	**16**	**16**	**8**	**-**			**-**	**-**	**-**	**550**	**-**	**200**		**-**

	SEMESTER-VIII (Duration 6 months)																	
Sr. No.	Course Title	Teaching Scheme						Examination Scheme										
								Theory								Practical		
		Theory			Practical			Theory			Internal			Total		Total		
		No. of lectures	Hours	Credits	No. of Lectures	Hours	Credits	Max.	Min.	Hours	Max.	Min.	Hours	Max.	Min.	Max.	Min.	Hours
1	Solid State Electronic Devices	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
2	Fundamentals of Nanocatalysis and Applications	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
3	Biomedical Applications of Nanobiotechnology	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
4	Energy Conversion and Storage Devices	4	4	4	4	4	2	80	28	3	20	7	1	100	35	50	18	4
5	Nanomagnetism and Spintronics	4	4	4	-	-	-	80	28	3	20	7	1	100	35			
6	Statistical Mechanics and Nanothermodynamics	2	2	2	-	-	-	40	14	2	10	4	0.5	50	18	-	-	-
	Total	**22**	**22**	**22**	**16**	**16**	**8**	**-**			**-**	**-**	**-**	**550**	**-**	**200**		**-**
	Grand Total	**44**	**44**	**44**	**32**	**32**	**16**							**1100**		**400**		

Note: - Practical examination will be conducted semester-wise.
Theory: 60 Lectures for Marks -100 (Credits: 04), 30 Lectures for Marks -50 (Credits: 02) (i.e. 15 lectures for 1 credit)
Practical: 30 lectures for 1 credit

SHIVAJI UNIVERSITY, KOLHAPUR
School of Nanoscience and Biotechnology
B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the paper: Semiconductor Physics

Sr. No.	Topics	No. of Lectures
Unit I	**Energy Bands and Charge Carriers in Semiconductors:** Bonding forces and energy bands in solids, Direct and Indirect semiconductors, variation of energy bands with alloy composition, Charge carriers in semiconductors: electrons and holes, effective mass, intrinsic and extrinsic materials, electrons and holes in quantum wells, The Fermi level, carrier concentration at equilibrium, temperature dependence, space charge neutrality, conductivity and mobility, Drift and resistance, effects of temperature and doping on mobility, High field effects.	**15**
Unit II	**Excess Carriers in Semiconductors:** Optical absorption, Luminescence, Direct recombination of electrons and holes, Indirect recombination and trapping, steady state carrier generation and Quasi Fermi levels, Diffusion processes, Diffusion and Drift of carriers, built in fields, The continuity equation, steady state carrier injection, diffusion length, The Haynes-Shockley experiment.	**15**
Unit III	**Junctions-I:** **Fabrication of pn junctions;** Thermal oxidation, diffusion, Rapid thermal processing, Ion implantation, CVD, Photolithography, etching, metallization, The contact potential, Space charge at a junction, qualitative description of current flow at a	**15**

	junction, Carrier injection, reverse bias breakdown, Zener and Avalanche breakdown	
Unit IV	**Junctions-II:** Capacitance of PN junctions, the Varactor diode, effects of contact potential on carrier injection, recombination and generation in the transition region, ohmic losses, graded junctions, Shottky barriers, rectifying contacts, ohmic contacts, heterojunctions, AlGaAs-GaAs heterojunction.	**15**

Reference Books:

1.Solid state electronic devices by B. G. Streetman.

2.Physics of semiconductor devices by S. M. Sze.

3.Solid State and Semiconductor Physics by McKelvey.

4.Principles of Electronic Materials and Devices by S. O. Kasap

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the paper: Laboratory Course-I

Sr. No.	Name of the Experiment
1.	Resistivity of thin film by two probe method
2.	PN junction diode characteristics
3.	Estimation of bandgap of semiconductor
4.	Modeling and simulation of Carrier concentrations in semiconductors
5.	Estimation of TEP of a semiconductor
6.	Modeling and simulation of mobility of charge carriers
7.	Excess electron and hole concentrations
8.	Modeling and simulation of Fermi level in semiconductors
9.	Photoluminescence in semiconductors
10.	Hall effect

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the paper: Carbonaceous Materials

Sr. No.	Topics	No. of Lectures
Unit I	**Carbon Nanotubes:** Introduction of Carbon Nanotube (CNT): Definition of CNT, bonding of carbon atoms, SP^3, SP^2, Deformed SP^2, Structure of Carbon Nanotubes, Chiral Vector; Types of Carbon nanotubes: Armchair, Zig-Zag and Chiral; Properties of Carbon Nanotubes: Electronic, Optical and Optoelectronic, Mechanical, Chemical and Electrochemical, Thermal and Thermoelectric; Opening, wetting and filling, doping, intercalation. Characterization of carbon nanotubes: Raman spectroscopy, NMR spectroscopy, AFM etc.	**15**
Unit II	**Synthesis Methods and Growth Mechanisms of Carbon Nanotubes:** High temperature methods: Arc discharge, General technical features of the production process, Growth Mechanism, Laser Ablation of Graphite; Low temperature method: Chemical Vapour deposition (CVD) process, Vapour liquid solid model, Catalytic role. **Purification and functionalization:** Methods of Purification, Methods of Functionalization (Chemical and Physical), Advantage of purification and functionalization, Separation of carbon nanotubes based on chirality: semiconducting, metallic; **Applications of Carbon nanotubes:** Field emission, Li-ion battery, Supercapacitor, Sensors, Solar cell, CNT-polymer composite.	**15**
Unit III	**Graphene:** Introduction of graphene: Definition and structure of graphene, Types of graphene: stacking AA,	**15**

	BB, AB dispersion relation, Single layer, Bi-layer, Few layer graphene; **Properties of graphene:** Optical: thickness dependency, optical conductivity, electric field tuneable transparency, Plasmon's and polaritons; Electrical: Boltzmann equation, ambipolar conduction, density of states and doping (electrostatic and chemical), quantum hall effect, thermal conductivity; Characterization of graphene: Transmission electron microscopy (TEM), Scanning tunnelling microscopy (STM), Raman Spectroscopy, NMR spectroscopy.	
Unit IV	**Synthesis Methods of graphene:** Epitaxial growth of graphene on Silicon carbide, Chemical vapour deposition (CVD) growth of graphene films, chemically derived graphene, Synthesis of graphene oxide: Hummer's method, Modified Hummer's method, Reduction of graphene oxide: Chemical methods and Physical methods, Electrochemical exfoliation, Nanotube slicing from solid state carbon sources. **Applications of graphene:** Graphene in the energy application: Li-ion batteries, Supercapacitors, Photovoltaic, Radio-frequency transistor, Photodetector, Modulator, Mode locked lasers; Other applications of graphene: Anti-corrosion coating, Antibacterial coating, catalyst, Sensors, Transparent Conductors.	**15**

Reference Books:

1. Graphene: Carbon in Two Dimensions, by Mikhail. Katsnelson (http://www.amazon.com/Graphene-Dimensions-Mikhail-I-Katsnelson/dp/0521195403)
2. Physics of Graphene, Editors: Aoki, Hideo, S. Dresselhaus, Mildred (Eds.) http://www.springer.com/in/book/9783319026329
3. Graphene:Synthesis, Properties, and Phenomena, by C. N. R. Rao (Editor), Ajay K. Sood (Editor) http://www.amazon.com/Graphene-Synthesis-Properties-Phenomena-

Rao/dp/3527332588/ref=pd_sim_b_2?ie=UTF8&refRID=1BE9W35KXA6TXMMMXVEP

4. Graphene Nanoelectronics, Metrology, Synthesis, Properties and Applications, Editors: Raza, Hassan (Ed.) http://www.springer.com/in/book/9783642204678
5. Graphene Nanoelectronics: From Materials to Circuits, Editors: Murali, Raghu (Ed.) http://www.springer.com/in/book/9781461405474
6. Carbon Nanotube and Graphene Device Physics, by H. S. Philip Wong (Author), Deji Akinwande (Author) http://www.amazon.com/Carbon-Nanotube-Graphene-Device-
7. Carbon Nanotube Electronics (Integrated Circuitsand Systems) by AliJavey (Editor), Jing Kong (Editor), http://www.amazon.com/Nanotube-Electronics-Integrated-Circuits-Systems/dp/0387368337%3FSubscriptionId%3D1VXT0MZ5J2QQ5RY3VV02%26tag%3Dgrapheneinfo-20%26linkCode%3Dxm2%26camp%3D2025%26creative%3D165953%26creativeASIN%3D0387368337
8. Polymer-Graphene Nanocomposites, Editor(s): Vikas Mittal http://pubs.rsc.org/en/content/ebook/978-1-84973-567-4#!divbookcontent
9. Physics and Chemistry of Graphene: Graphene to Nanographene,Toshiaki Enoki,Tsuneya Ando http://www.crcpress.com/product/isbn/9789814241489

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the paper: Laboratory Course-II

Sr. No.	Name of the Experiment
1.	Raman spectroscopy of graphene.
2.	IR and Raman spectroscopy carbon nanotubes.
3.	Synthesize the graphene oxide by Modified Hummers Method.
4.	Synthesis of reduced graphene oxide by chemical reduction of graphene oxide.
5.	Simulation of Graphene
6.	Simulation Study of Carbon Nanotubes (CNTs)
7.	Functionalization of carbon nanotubes.
8.	Synthesis of Carbonaceous materials from various organic waste.
9	Simulation Study of various carbonaceous materials.
10	Designing and construction of paper battery.

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the Paper: - Fundamental of Nanobiotechnology

Sr. No.	Topics	No. of Lectures
Unit I	**Biological synthesis of nanomaterials and their applications:** Introduction to nanobiology and nanobiotechnology. Biological synthesis of nanoparticles using bacteria, fungi, plants, purified enzymes, biological templates and S layer. Metal and Metal oxide Nanoparticles-Silver, gold, cerium oxide, titanium oxide, zinc oxide and magnetic nanoparticles. Biological applications of inorganic nanoparticles. (Metal / metal oxide)- antibacterial / antifungal / antiviral and anticancer activity-mechanism. **Introduction to biological nanoparticles and their applications:** Exosomes, lipoproteins, ferritin, viruses, magnetosomes. Biological nanomotors and Machines, mechanisms of biological machines, protein assemblies: muscle myosin, kinesin, nerve, ATPase, bacteriorhopsin, Hemoglobin, dynein, cilia. **Bacterial flagella:** structure and function; nanomotor. Ion channels: nanopores of high specificity.	**15**
Unit II	**Nanomaterial- Biomolecule interactions and Biosensors:** **Nanomaterial- Biomolecule interactions:** Protein, lipids, RNA and DNA, Small molecule/nanomaterial, protein-Nanomaterial interactions, Nanomaterial– cell interactions, Manifestations of surface modification (Polyvalency). Surface modified nanoparticles, Peptide/DNA coupled nanomaterial. **Nanodiagnostics: Biosensor and nanobiosensor:** basic	**15**

	concepts, principle and types. Enzyme–metal NP hybrids for biosensing and for the generation of nanostructures, Biomolecule–semiconductor NPs for biosensing. Different types of nanobiosensors; CNT biosensor, DNA nanosensor, Nanowire biosensor, application of nanodiagnostics. Nanobiosensors for medical diagnostics. Nanoprobes for analytical applications, Nanoarrays for diagnostics. Detection of single DNA, self-assembled protein nanoarrays, protein nanobiochip, nanoparticles for molecular diagnostics, DNA nanomachines.	
Unit III	**Nanotechnology applications in Agriculture** Nanotechnology in Agriculture: nanotechnology in pesticides, fertilizers, and insecticides. Traditional chemical fertilizers vs. nanofertilizers. Potential of nanofertilizers and examples. Various types of nanomaterials utilized in agriculture, examples of nanomaterials used in pesticides and insecticides. Nano-biostimulants and soil enhancers. Macro and micro nutrients required by plant. Nano-nutrient uptake and regulation in Plants. Nano-enabled technologies and abiotic stress management. Nanobiotechnology for Crop improvement. Precision delivery Systems. Diagnostics and sensing. Nanotechnology for environment: contamination detection and remediation. Precision farming, Smart delivery system. Toxicity Studies related to nanoparticles uptake by plants.	**15**
Unit IV	**Nanotechnology and its application in food industry:** **Nanotechnology in food production:** food and new ways of food production, engineering food ingredients to improve bioavailability, nanocrystalline food ingredients. Nanotechnology in food processing, **Nanotechnology in food packaging,** need of food packaging, Physical properties of	**15**

	packaging material: strength and barrier properties, antimicrobial functionality. Quality assessment. Advantages of nanomaterials in food packaging, applications, natural biopolymers, smart nanomaterials for food packaging. Food safty indication. Nanobased Agri and Food Products, food preservation and toxicity. Nanosensor for pathogens and toxins detection. Adulterant detection using nanosensor.	

Reference Books:

1. Principles and techniques of Biochemistry and Molecular biology, 7th Edition, Keith Wilson and John Walker. Cambridge University Press, 2010
2. Analytical Techniques in Biochemistry and Molecular Biology, Rajan Katoch, Springer, 2011
3. Basic Cell Culture Protocols, Editors: Helgason, Cheryl D., Miller, Cindy L, Springer 2005
4. Proteomic and Metabolomic Approaches to Biomarker Discovery, Haleem J Issaq, Academic press. 2013
5. Challa Kumar- Biological and pharmaceutical Nanomaterials, Wiley-VCH Verlag GmbH & Co. KGaA.
6. Cato T. Laurencin and Lakshmi S. Nair, Nanotechnology and Tissue Engineering The Scaffold, CRC Press taylor & Francis Group.
7. Peter X Ma, Scaffolds for tissue fabrication, materials today Volume 7, Issue 5, May 2004, Pages 30–40
8. K. K. Jain, Nano Biotechnology, Horizions Biosciences, 2006
9. Martin C. Woodle, Patrick Y. Lu Nanoparticles deliver RNAi therapy, materials today, Volume 8, Issue 8, Supplement, August 2005, Pages 34–41
10. C. Kumar, Nanomaterials for medical diagnosis and therapy, Wiley –VCH, 2007, USA
11. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester; 2002.
12. Biosensors and modern biospecific analytical techniques, Wilson & Wilson's Comprehensive Analytical Chemistry; Ed. L Gorton; Elsevier, Amsterdam, London; 2005.
13. The Immunoassay Handbook; Ed. David Wild; 3rd ed.; Amsterdam: Elsevier; 2005.
14. Electrochemical Methods: Fundamentals and Applications; Allen J Bard and Larry R Faulkner; Wiley, New York, Chichester: 2nd ed.; 2001.

15. Ultrathin Electrochemical Chemo- and Biosensors: Technology and Performance in Springer Series on Chemical Sensors and Biosensors; Volume Two; Ed. Vladimir M. Mirsky; Springer, Berlin; 2004
16. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
17. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
18. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.
19. Bernard R. Glick and Jack J. Pasternak (2002). Molecular Biotechnology, Panima Publishing House, New Delhi. PG & Research Department of Biotechnology, National College (Autonomous), Tiruchirappalli – 620001. 18
20. Garrison C, Fathman F and Fitch W. (1982). Isolation- Characterization and utilization of T – Lymphocyte clones, Academic Press
21. Goldsby R. A. Kindt T.J, Osborne B. A and Kuby J. (2003). Immunology, W.H. Freeman and company.
22. Griffiths A. J, Miller J.H, Suzuki D.T, Lewontin R.C and Gelbart W.M. (2000). An introduction to Genetic analysis, W. H.Freeman and Company.
23. Masters J.R.W. (2000), Animal Cell culture, Oxford University Press.
24. Puher A. (1993). Genetic Engineering of animals (Ed.), VCH Publishers-WeinheimFRG.
25. Ranga M.M. (2003). Animal Biotechnology.
26. Springer T. A. (1985), Hybridoma Technology in Biosciences and Medicine, Plenum Press, New York.
27. Watson J.D, Gilman M, Witknowski J and Zoller M. (1992). Recombinant DNA, Scientific American Books, New York.
28. Watson J.D, Hopkins N.H, Roberts J.W. Steitz J. A and Weiner A.M. (2002). Molecular Biology of gene, Benjamin / Cummings.

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the paper: Laboratory Course-III

Sr. No.	Name of the Experiment
1	Synthesis of nanoparticles using bacterial cells, its extracellular proteins and characterization
2	Preparation of nanoparticles using fungi, Its extracellular proteins and characterization
3	Preparation of various metal nanoparticles for the study of their biological activity
4	Estimation of antibacterial activity of metal nanoparticles
5	Preparation of nanoparticles using plant extract and its characterization
6	Estimation of antifungal activity of metal nanoparticles
7	Biogenic Synthesis of metal oxide nanoparticles
8	Synthesis of gold nanoparticles and its assembly/Conjugation with biomolecules i.e. BSA
9	SDS PAGE gel shift assay for study of nanoparticle-biomolecule assembly

Reference Books:

1. Charles P. Poole Jr. and Franks. J. Qwens (2003) Introduction to Nanotechnology, Wiley
2. Ehud Gazit (2007) Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology. Imperial college Press
3. Bharat Bhushan (2007) Springer Handbook of Nanotechnology. Springer Verlag.
4. Challa S., S. R. Kumar, J. H. Carola (2006) Nanofabrication towards biomedical application: Techniques, tools, Application and impact. John Wiley and sons.
5. Robert A. Freitas Jr (2003) Nanomedicine, Vol. I: Basic Capabilities.
6. Neelina H. Malsch (2005) Biomedical Nanotechnology. Taylor and Francis. CRC press.

7. Patrick Boisseau, Marcel Lahmani (2009) Nanoscience: Nanobiotechnology and
8. Ralph S. Greco, Fritz B. Prinz, R. Lane Smith (Editors) (2004) Nanoscale Technology in Biological Systems. CRC Press
9. Harry F. Tibbals (2010) Medical Nanotechnology and Nanomedicine. CRC Press
10. Research articles from various journals and databases

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the Paper:- Coating Technology, Nanocoatings and Applications

Sr. No.	Topics	No. of Lectures
Unit I	**Introduction to Coating Technology:** Definition of coatings, different types of conventional coatings (examples and function), coating formulations, Factors influencing formulation (viscosity, rheology and types). Role of surface chemistry in coatings. Terminology involved with conventional coating technology and their significance with examples. (solvent/carrier, binders, additives, fillers and solid contents). **Introduction to Nanocoatings:** Definition, difference between conventional coatings and nanocoatings. Functional coatings, types and significance. Role of solvent, surface passivation) in nanoformulation. Effect of particle size and shape in nanocoatings (stabilizers). Smart coatings definition, applications with example. **Techniques and Tools for Nanocoating:** Sol-gel, dip coating, spin coating, spray pyrolysis and their types, chemical vapor deposition (CVD), SILAR, plasma and types (pulsed plasma nanocoating), electrodeposition (anodization), electroplating, electrospinning, hydrothermal, solvothermal.	**18**
Unit II	**Functional Nanocoatings I:** Lotus effect, discovery and origin of self cleaning surface coatings. Contact angle, theory of superhydrophilic, hydrophilic, hydrophobic and superhydrophobic (Young's equation, Wenzel's and Cassie-Baxter equation) Self	**18**

	cleaning glass (solar panel, energy saving buildings, slef cleaning/dirt free fabrics) Anti-microbial Nanocoatings: Introduction, Nano-Coating use Against SARS Virus, Application of Ag Nanoparticles as Antibacterial Coating, Using TiO2 Nano-Particles to Decrease Environmental Contaminations, Anti-fouling Nanocoatings: Introduction, Applications of Anti-fouling Superhydrophobic Nanocoatings: Introduction, Superhydrophobic surface, self cleaning surfaces, methods for surface roughening: Nakajima, Erbil and Patankar approaches. Applications of hydrophobic nanocoatings companies and products. UV-resistant Nanocoatings: Introduction, Necessity of UV-resistant nanocoatings, Types of UV-resistance Nanocoatings, mechanism of protection. Applications Conductive Nanocoatings: Introduction, Necessity of Conductive Nanocoatings, Conductivity fundamentals, Coating Build-Up, Control of optoelectronic properties, Methods of Coatings Characterization, Properties of Coatings, Applications of conductive nanocoatings in biosensors.	
Unit III	**Functional Nanocoatings II and III:** Anti-corrosion Nanocoatings: Introduction, Principle of prevention & protection of Corrosion, Advantages and disadvantages of Anti-corrosion Nanocoatings, Advanced protective coatings for aeronautical applications Thermal barrier and flame retardant Nanocoatings: Introduction, Applications of Thermal barrier and flame retardant Nanocoatings. Role of gas barrier coating in flame retardant and anti-corrosion.	**14**
Unit IV	**Smart Nanocoatings:** Self cleaning surfaces like light saving glass buildings. Self healing nanocoating. Superhydrophobic-anti dust nanocoatings. Optoelectronics	**10**

	nanocoatings. **Hard and Soft Nanocoatings:** Anti-finger print, anti-abrasion, anti-skratch, anti-static nanocoatings.	

Reference Books:

1. COATINGS TECHNOLOGY FUNDAMENTALS, TESTING, AND PROCESSING TECHNIQUES, Chapter 1: Edited by Arthur A. Tracton, CRC Press, Taylor & Francis Group.
2. Nanocoatings: Principles and practice By steven abbott and Nigel Holmes
3. Bioinspired Intelligent Nanostructured Interfacial Materials, Lei Jiang and Lin Feng
4. PAINT AND SURFACE COATINGS Theory and Practice, Second edition: Editors: R LAMBOURNE and T A STRIVENS, Woodhead Publishing Limited, Cambridge, England.

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the Paper: -Functional Nanomaterials

Sr. No.	Topics	No. of Lectures
Unit I	**Semiconductor quantum dots and metal organic frameworks** **Semiconductor quantum dots**- Introduction, Magic size cluster (shape and composition control), Basic properties of nanocrystals, Multishell semiconductor nanocrystals, Applications of quantum dots **Metal Organic Frameworks (MOF)-** Introduction, advantages, disadvantages, methods of synthesis, Structural originality of MOFs, properties, applications	**15**
Unit II	**Nanotubes, nanowires and nanofibers** **TiO_2 nanotubes** Introduction, Properties of TiO_2 nanotube arrays: Structural, Elemental, Mechanical, Optical, and Electrical, Applications, Inorganic nanowires **Nanofibers** Introduction, Electrospinnnig process, Nanofiber yarns and fabrics, Applications of electrospun fibers, Nanofibers for Tissue Engineering Scaffolds, Nanofibers for Chemical/Bio Protective Membranes, Nanocomposite Fibers for Structural Applications	**17**
Unit III	**Carbon fibers and nanotubes, Inorganic nanofibers and Nanocomposites** **Carbon fibers and nanotubes** Types of fibers, whiskers and nanotubes, Applications	**18**

	Organic polymer nanocomposites Introduction, Polymerization, Interfacial area, Nanofilled composites design and applications, Enhanced polymer nanocomposites **Metal and Ceramic nanocomposites** Inorganic nanofibers-silicon carbide, boron nitride nanotubes and fibers, Cermets, Concrete- carbon fiber and nanotube-reinforced concrete, nanocomposite cements	
Unit IV	**Natural nanocomposites** Skin of the sea cucumber, hard natural nanocomposites **Clay nanocomposite materials** Polypropylene-clay nanocomposite, Montmorillonite clay nanocomposite, Halloysite nanotube clay nanocomposite	**10**

Reference Books:

1) Semiconductor Nanocrystal, Quantum Dots: Synthesis, Assembly, Spectroscopy and Applications by Andrey L. Rogach (Ed.), Springer Publisher
2) TiO_2 Nanotube Arrays: Synthesis, Properties, and Applications by Craig A. Grimes and Gopal K. Mor, Springer Publisher
2) Nanotubes and Nanofibers; Advanced Materials Series, Series Editor: Yury Gogotsi, Drexel University, Philadelphia, Pennsylvania, USA, Nanotubes and Nanofibers by Yury Gogotsi
3) Hybrid porous solids: past, present, future by Gerard Ferey, Chemical Society Reviews, 37 (2008) 191-214. DOI: 10.1039/b618320b
4) Introduction to Nanoscience and Nanotechnology by Garbor L. Hornyak, Harry F. Tibbals, Joydeep Dutta, John J. Moore, CRC Press, Boca Raton, FL, USA, 2009.
5) Nanotubes and Nanowires, CNR Rao and Govindraj, RSC Publishers

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the paper: Laboratory Course-IV

Sr. No.	Name of the Experiment
1	Synthesis of CdSe-CdS core shell QD by hot injection method
2	Synthesis of TiO_2 nanotubes array by electrochemical anodization
3	Electrodeposition of MnO_2 by potentiodynamic method
4	Deposition of PbS thin film by SILAR technique
5	Preparation of TiO_2 thin film by spray pyrolysis technique
6	Synthesis of ZnO nanorod thin film using microwave method
7	Synthesis of TiO_2 nanofibers by electrospinning technique
8	Mechanical exfoliation of graphite into graphene

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VII

Title of the Paper:- Quantum Mechanics at Nanoscale

Sr. No.	Topics	No. of Lectures
Unit I	**Problems on Quantum Mechanics:** Solved problems on matter waves, Schrodinger equation, wave-particle duality, Heisenberg Uncertainty principle, Operators and related topics.	**15**
Unit II	**Nanomaterials Continuum:** Basic Quantum Mechanics and Solid States, Materials Properties and Phenomenon at macro and nanoscale, Quantization of Energy, Bohr Exciton Radius, Nano quantum prospective, Particle in a box, Two-Dimensional Quantum System, Zero-dimension materials: clusters, cluster particle in a box, Optical Properties of Clusters, Dipolar Plasma Resonance, Other Physical Properties and Phenomena: Surface Energy, Thermal Properties. Quantum wire, Quantum Size Effects and Scaling laws.	**15**

Reference Books:

1. Introduction to Nanoscience and Nanotechnology. By Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore.
2. Introductory Quantum Mechanics for Applied Nanotechnology By Dae Mann Kim, 2016
3. Concepts of Modern Physics, Arthur Beiser, Ahobhit Mahajan, S. Rai Choudhury, Sixth Edition, Tata McGraw Hill Education Private Ltd.
4. Modern Physics, S. L. Kakani and Shubhra Kulkarni, 2006, Viva books Private Ltd.
5. Modern Physics, D. L. Sehgal, K. L. Chopra and N. K. Sehgal, Reprint 1995, Sultan Chand & sons.

6. Introduction to Modern Physics, F. K. Richtmyer, E. H. Kennard, John N. Cooper, Sixth Edition, Tata McGraw Hill Education Private Ltd
7. A Text book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, 2nd Edn.,2010, Tata McGraw Hill,
8. Quantum Mechanics, Leonard I. Schiff, 3rdEdn. 2010, Tata McGraw Hill.
9. Quantum Mechanics Theory and Applications, A. K. Ghatak and S. Lokanathan, Third Edn.1995, Macmillan India Ltd.

Shivaji University, Kolhapur,

School of Nanoscience and Technology,

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the Paper:- Solid State Electronic Devices

Sr. No.	Topics	No. of Lectures
Unit I	**Transistors and Microwave Devices:** Bipolar junction transistor (BJT), frequency response and switching of BJT, Single electron transistor, Field effect transistor (JFET), MOSFET and MESFET devices: structure and its operation, Tunnel diode, Resonant tunneling and NDR effects in nanostructures, Transferred electron devices-Gunn diode, Nano-CMOS technology.	**15**
Unit II	**Photonic Devices:** Radiative Transitions and Optical Absorption, Light emitting Diodes, OLED, Infrared LED, Photodetector, Photoconductor, Photodiode, Semiconductor Lasers, Laser Operation, population inversion, carrier and optical confinement, optical cavity	**15**
Unit III	**Nanopiezotronics, Nano-generators** Piezoelectric, Electrostrictive and magnetostrictive effects, important materials exhibiting the properties and their applications sensors and actuator devices, Piezoelectricity of ZnO nanowires, combination of piezoelectric and semiconducting properties, Piezotronic nanodevices using ZnO nanowires, chemical/humidity nanosensors, ZnO nanowires, nano-generator, Flexible nanogenerator, and power fibers.	**15**

Unit IV	**Micro-Electro-Mechanical-Systems (MEMS):** What is MEMS, MEMS technology? A brief history of MEMS, Introduction of MEMS sensors, physical/chemical/biological MEMS sensors, Resonant mechanical sensors, accelerometers, gas flow sensors, sensing principle, MEMS design, MEMS in automobiles	**15**

Reference Books:

1. Semiconductor Devices: Physics and Technology 2nd Edition, S. M. Sze
2. Modern Digital Electronics: R.P.Jain
3. Introduction to Semiconductor Devices by M. S. Tyagi
4. Optical Electronics by Ajoy Ghatak and K. Thyagrajan, Cambridge University Press.
5. Microsystems and nanotechnology, Xudong Wang, Jun Zhou, Zhong Lin Wang, Springer Publication.
6. Advances in Non-volatile Memory and Storage Technology, Yoshio Nishi, Woodhead Publishing Series in Electronic and Optical Materials (Elsevier), 2014.
7. Selected Advances in Nanoelectronic Devices: Logic, Memory and RF, Mojtaba Joodaki, Springer, 2010.

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the paper: Laboratory Course-I

Sr. No.	Name of the Experiment
1.	BJT Characteristics
2.	FET Characteristics
3.	Modeling and simulation of Solar cell
4.	Modeling and simulation of PN Junction
5.	Modeling and simulation of MOSFET device
6.	Studies on TiO2 Memristor
7.	Studies on Liquid memristor devices
8.	Studies on Physical sensors
9.	Studies on Chemical sensors
10.	Studies on MEMS device

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the Paper:- Fundamentals of Nanocatalysis and Applications

Sr. No.	Topics	No. of Lecture
Unit I	Introduction to catalysis, classifications, heterogeneous catalysis, reaction on the solid surfaces, adsorption isotherms, physisorption and chemisorptions., reaction mechanism and kinetics of the heterogeneous catalytic reactions, activation energy (Arrhenius equation, Eyring equation).	**15**
Unit II	Catalytic activity (bulk and nanoscale), catalytic activity determination for metal/metal oxide nanostructures. Langmuir-Hinshelwood mechanism for nanocatalyst, Mass transport, diffusion controlled process, catalytic efficiency and turnover frequency, inhibition. Application of metal nanoparticles in organic reactions (Heck and Suzuki-Maurya reactions), environmental remediation.	**18**
Unit III	Introduction of photocatalysis, Basics of electrochemistry and photochemistry, Electronics structure and photoabsorption, Kinetics and photocatalytic activity, Jablonskii diagram, Structure of photocatalysts and solar spectrum analysis. Fundamental understanding of semiconductor interfaces, Principles and relevance to photoelectrochemical and photocatalysis mechanism, Properties of good photocatalysts, Advantages of photocatalysts, types of photocatalysts, Homogeneous,	**15**

	heterogeneous, carbonaceous and plasmonic photocatalysts.	
Unit IV	Photocatalysts design and synthesis, Application of photocatalysis, Self cleaning, purification of water and air, Photoreduction of CO2 and fuel production, antimicrobial use. Characterization and performance of photocatalysts, Fabrication of water purification reactor, Industrial development of photocatalysts, Environmental remediation, Future possibilities.	**12**

Reference Books:

(1) J. P. Simons, Photochemistry and Spectroscopy, Wiley, 1971.

(2) J. G. Calvert, J. N. Pitts, Photochemistry, Wiley & Sons, New York, 1966.

(3) N. Serpone, E. Pelizzetti (Eds.), Photocatalysis. Fundamentals and Applications, Wiley, New York, 1989.

(4) K. K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, Wiley, New York, 3rd Edition, 2002.

(5) Nick Serpone and Ezio Pelizzetti, Photocatalysis: Fundamentals and Application, Wiley Interscience, 1st Edition, 1989

(6) Photoelectrochemistry, Photocatalysis and Photoreactors Fundamentals and Developments, Schiavello, Mario (Ed.) Springer,1985.

(7) Photoelectrochemical solar cells, Suresh Chandra, Gordon and Breach Science Publishers, 1985.

(8) Physical Chemistry of Surfaces , W. Adamson, Wiley Intersciences,(5th edition) 1990.

(9) Physical chemistry - Peter Atkins, Julio de Paula , 7th Edition Oxford University Press.

(10) Catalytic Chemistry, B.C. Gates, John Wiley and Sons Inc. (1992)

(11) Nanoparticles and Catalysis; D. Astruc, Wiley-VCH, 2008

(12) Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age Publishers

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the paper: Laboratory Course-II

Sr. No.	Name of the Experiment
1	Adsorption isotherms, validation of Langmuir and Freundlich isotherms
2	Determination of order of reaction for acid catalyzed iodination of Acetone.
3	Measurement of Ag/Pt/Pd nanoparticle catalysed reduction of 4-nitro phenol to 4-amino phenol spectrophotometrically and determination of pseudo-first order kinetics.
4	Synthesis of C-C bond by Pd nanoparticle catalyzed Suzuki-Miyaura coupling of boronic acid and iodobenzene.
5	Calculation of activation energy of a nanocatalyzed reaction from the given data.
7	Calculation of entropy of activation, enthalphy of activation for a nanocatalyzed reaction.
8	Measurement of TiO2/ZnO/Fe2O3 nanoparticle catalyzed photodegradation of dye and calculation of efficiency.

Reference Books:

1. M. Sc. Nanocatalysis Laboratory Manuals (School of Nanoscience and Technology)

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the Paper:-Biomedical Application of Nanobiotechnology

Sr. No.	Topics	No. of Lectures
Unit I	**Cancer as a disease**: The difference between malignant and benign tumor, the difference between normal cell function and malignant cells, cancer invasion, migration, angiogenesis, and metastasis. Causative agents of cancer. Types of cancer. Concept of oncogenes, proto-oncogenes, Gross tissue level changes in cancer, cellular events, and molecular pathology. **Nanotechnology in cancer**: Early detection of cancers using nanotechnology, Biomarker development by nanoprobes. Conventional chemotherapy drugs: their mechanism and limitations, Nanodrugs in cancer chemotherapy in detail (synthesis, action, advantages, and examples). Potential of nanotech application in cancer surgery. Introduction to genome /proteome analysis for cancer	**15**
Unit II	**Applications of nanotechnology in therapeutics I** **Introduction to Nanomedicine-**Potential applications and Challenges **Nanobiotechnology for drug and gene delivery:** Basics of drug delivery, Types of nanocarriers- metal nanoparticle, metal oxide nanoparticles, lipid, exosomes, dendrimers-based drug delivery system, and miscellaneous. Advantages of nanomaterial based drug delivery system. Mechanism and drug targeting strategies for site-specific drug delivery, passive and active targeting, time and rate-controlled drug delivery. Nanocarriers for gene delivery. **Polymer nanoparticles for drug and small silencing RNA delivery**: classification and types of polymeric nanocarriers. Different methods of preparation of polymeric nanoparticles. Polymer nanoparticles for	**15**

	miRNA, antisense miRNA (antagomir), siRNA delivery, and shRNA delivery. Advantages and disadvantages associated with the use of polymer NPs for drug delivery. Mechanism of drug delivery to tumours by polymer nanoparticles.	
Unit III	**Applications of nanotechnology in therapeutics II** Protein and peptide-based compounds for cancer. Vaccination, cell therapy, gene therapy. Hyperthermia treatment for cancer. Nanotechnology in tissue engineering, tissue regeneration, growth and repair, Tissue bioengineering; Future understanding for treatment. Nanotechnology in dentistry and bone substitutes**.** Implants and Prostheses. Reconstructive Intervention and Surgery. Nanorobotics in Surgery. Photodynamic Therapy. Neuroelectronic Interfaces. Applications of nanotechnology in cosmetics.	**15**
Unit IV	**Nanotoxicology and biosafety.** Introduction to Biocompatibility, Toxicity, Cytotoxicity, Carcinogenicity. Fate of nanomaterials in the body: short term and long term effects. Safety Testing of Biomaterials. Introduction to Nanotoxicology: types of nanomaterial causing toxicity. Basics of cellular and organ level toxicity, effect of size, shape, surface properties and composition on toxicity of nanomedicines. Case studies: Ag, ZnO, TiO_2, Quantum dots, carbon-based nanomaterials, polymeric, protein and lipid nanoparticles. Experimental models in nanotoxicology - *In vitro* and *In Vivo* models. Toxicity mechanisms - mechanisms for radical species production, general genotoxicity mechanisms, detection and characterization of genotoxicity.	**15**

Reference Books:

1. Challa Kumar- Biological and pharmaceutical Nanomaterials, Wiley-VCH Verlag GmbH & Co. KGaA.
2. Cato T. Laurencin and Lakshmi S. Nair, Nanotechnology and Tissue Engineering The Scaffold, CRC Press taylor& Francis Group.

3. Peter X Ma, Scaffolds for tissue fabrication, materials today Volume 7, Issue 5, May 2004, Pages 30– 40
4. K.K.Jain, Nano Biotechnology, Horizions Biosciences, 2006
5. Martin C. Woodle, Patrick Y. Lu. Nanoparticles deliver RNAi therapy, materials today, Volume 8, Issue 8, Supplement, August 2005, Pages 34–41
6. C. Kumar, Nanomaterials for medical diagnosis and therapy, Wiley –VCH, 2007, USA
7. Harry F. Tibbals (2010) Medical Nanotechnology and Nanomedicine. CRC Press
8. Assessing Nanoparticle Risks to Human Health, Gurumurthy Ramachandran, Elesvier, 2011
9. Nanotechnology: Environmental Health and safety, Risks, Regulation and Management, Matthew Hull and Diana Bowman, Elsevier, 2010
10. Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, CRC Press, 2013
11. Principles and Methods of Toxicology, A.W. Hayes, Informa Health care, 2008

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the paper: Laboratory Course-III

Sr. No.	Name of the Experiment
1	Conjugation of nanoparticles with nucleic acids, DNA/RNA, Amino acids
2	Conjugation between PGLA and tetracycline
3	Preparation of PGLA-tetracycline functional nanoparticles using emulsion diffusion method/ nano-precipitation/dialysis method
4	Characterization of tetracycline modified nanoparticles
5	Synthesis and characterization of CdS quantum dots by reverse micelles method
6	Synthesis of oil based nanoemulsion drug delivery system
7	Testing the cell viability of metal oxide nanoparticles using tissue culture technique
8	In vitro study of the effect of nanoparticles on mammalian cells and tissues
9	MTT Assay for cell viability and growth
10	Cell counting and Cell staining using PI-DAPI

Reference Books:

1. K. Youell and Firman, Nanotechnology perception 3 (2007) 75,96. Comprehensive overview of motors in biology
2. Jeremy Ramsden, Essentials of nanotechnology
3. Rammohan Devulapally and Ramasamy Paulmurugan, Polymer nanoparticles for drug and small silencing RNA delivery to treat cancers of different phenotypes WIREs Nanomed Nanobiotechnol 2014, 6:40–60. doi: 10.1002/wnan.
4. Itamar Willner, Bernhard Basnar and Bilha Willner Nanoparticle–enzyme hybrid systems for nanobiotechnology FEBS Journal 274 (2007) 302–309.

5. Nanotechnology: Technology Revolution of 21st Century by Rakesh Rathi, published by S. Chand.
6. Introduction to Nanoscience, by Stuart Lindsay.
7. Introduction to Nanomaterials and nanotechnology by Vladimir Pokropivny, RynnoLohmus, Irina Hussainova, Alex Pokropivny and Sergey Vlassov.
8. Nanomaterials by A.K. Bandyopadhyay; New Age International Publishers.
9. Nanotechnology by Mark Ratner and Daniel Ratner, Pearson Education.
10. Nano Essentials, T.Pradeep /TMH
11. Bharat Bhusan, "Springer Handbook of Nanotechnology", springer, Newyork, 2007.
12. Hari Singh Nalwa, "Encyclopedia of Nanotechnology", USA 2011.
13. James A. Schwarz, Cristian I. Contescu, Karol Putyera, "Dekker encyclopedia of nanoscience and nanotechnology" CRC Press, 2004.
14. Charles P. Poole Jr. and Franks. J. Qwens (2003) Introduction to Nanotechnology. John Wiley and Sons.
16. Ehud Gazit (2007) Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology. Imperial college Press
17. Bharat Bhushan (2007) Springer Handbook of Nanotechnology. Springer Verlag.
18. Challa S., S. R. Kumar, J. H. Carola (2006) Nanofabrication towards biomedical application: Techniques, tools, Application and impact. John Wiley and sons.
21. Robert A. Freitas Jr (2003) Nanomedicine, Vol. I: Basic Capabilities.
22. Neelina H. Malsch (2005) Biomedical Nanotechnology. Taylor and Francis. CRC press.
23. Patrick Boisseau, Marcel Lahmani (2009) Nanoscience: Nanobiotechnology and Nanobiology. Springer Publishers.
24. Ralph S. Greco, Fritz B. Prinz, R. Lane Smith (Editors) (2004) Nanoscale Technology in Biological Systems. CRC Press
25. Harry F. Tibbals (2010) Medical Nanotechnology and Nanomedicine. CRC Press Assessing Nanoparticle Risks to Human Health, Gurumurthy Ramachandran, Elesvier, 2011
26. Nanotechnology: Environmental Health and safety, Risks, Regulation and Management, Matthew Hull and Diana Bowman, Elsevier, 2010
27. Nanotechnology: Health and Environmental Risks, Jo Anne Shatkin, CRC Press, 2013
28. Principles and Methods of Toxicology, A.W. Hayes, Informa Healthcare, 2008

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the Paper: - Energy Conversion and Storage Devices

Sr. No.	Topics	No. of Lectures
Unit I	**Batteries:** Primary batteries, Rechargeable batteries, Electrochemical energy storage: cell reaction, Laws, Parameters, thermodynamics parameters, kinetic parameters, Polarization, Heat effects, Types of batteries (Lead-acid, Ni/Cd, Ni/metal hybrid), charging methods and techniques, characteristic curves, Lithium batteries: chemistry and physics of lithium batteries, anode and cathode materials, applications.	**15**
Unit II	**Supercapacitors:** Similarities and differences between supercapacitors and batteries, Energetics, Double layer electrostatic capacitor, Pseudocapacitance, origin, kinetic theory, RuO2 as a material for electrochemical capacitors, Regon plot, electrolyte factor, energy density and power density, Impedance of a pseudocapacitance.	**15**
Unit III	**Solar Photovoltaics:** P-N junction under illumination, Light generated current, I-V equation, Characteristics, Upper limits of cell parameters, losses in solar cells, equivalent circuit, effects of various parameters on efficiency, Solar cell design, Design for high Isc, Anti Reflective coating (ARC), Design for high Voc and fill factor, Analytical techniques; solar simulator, Quantum efficiency,	**15**

	Minority carrier lifetime and diffusion length measurement.	
Unit IV	**Sensitized and Polymer Photovoltaics:** Dye sensitized solar cells, advantages and disadvantages, Quantum dot sensitized solar cells, Perovskite sensitized solar cells, Planar and bulk heterojunction polymer solar cells, Exciton generation and dissociation, Advantages, disadvantages and types of materials.	**15**

1. Solar photovoltaics, Fundamentals, Technologies and Applications by Chetan Singh Solanki, PHI Learning Private Limited, Delhi-110092.
2. Polymer photovoltaics, a practical approach by Fredrik C. Krebs, Spie Press, Bellingham, Washington USA.
3. Organic Solar Cells, Theory, Experiment, and Device Simulation by Wolfgang Tress, Springer.
4. Dye Sensitized Solar Cells by K. Kalyansundaram, EPFL Press, A Swiss academic publisher distributed by CRC press.
5. Solar cells- Dye-sensitized Devices by Leonid A. Kosyachenko, Published by Intech, Janeza Trdine 9, 51000 Rijeka, Croatia.
6. Battery Technology Handbook by H. A. Kiehne , Marcel Dekker, Inc. , New York, Basel.
7. Electrochemical Supercapacitors, Scientific fundamentals and Technological Applications by B. E. Conway, Kluwer Academic/ Plenum Publishers, New York, Boston, Dordrencht, London, Moscow.

B. Sc. –M.Sc. in Nanoscience and Technology,
(5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the paper: Laboratory Course-IV

Sr. No.	Name of the Experiment
1	Synthesis of electrode material for various energy storage devices.
2	Coin cell fabrication.
3	Polyaniline nanofiber synthesis by electrodeposition method.
4	Study of inverse square law of radiation using solar cells.
5	Study of IV characteristics of solar cells.
6	Studies of electrolysis of water and electricity generation by fuel cell.
7	Fabrication of MnO_2 thin film pseudocapacitor and study of its CV cycle .
8	Determination of power density and energy density from given data.
9	Study of Regone plot.
10	Synthesis of Copper oxide by anodization method.

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the Paper:- Nanomagnetism and Spintronics

Sr. No.	Topics	No. of Lecture
Unit I	**Fundamentals of Nanomagnetism and spintronics:** **Magnetism in small structures:** Single domain particles, superparamagnetism, blocking temperature, magnetic ultrathin films, magnetic surface and interface anisotropies. **History and overview of spin electronics:** Classes of magnetic materials; The early history of spin; Quantum Mechanics of spin; Spin relaxation; Spin injection, spin accumulation, and spin current, Spin dependent transport.	**15**
Unit II	**Spintronic devices:** mechanism of GMR, spin dependent scattering of electrons, exchange biasing, spin valves, quantum tunneling, tunneling magnetoresistance (TMR), magnetic oxides and phase transformations: colossal magnetoresistance (CMR), Spin hall effect, Spin electronic devices.	**15**
Unit III	**Magnetic data storage:** Magnetic recording overview, recording medium, particulate recording media, thin film recording materials, longitudinal versus perpendicular recording, write heads, read heads, magnetic random access memory (MRAM), outlook and fundamental limits to recording, patterned media.	**15**

Unit IV	**Nano Biomagnetism:** Materials for biomagnetism, targeting, functionalization of magnetic nanoparticles, magnetic separation, manipulation of magnetic particles in fluids magnetic twizzers, drug and gene delivery, magnetic resonance imaging, hyperthermia, magnetic biosensors, biological assay system, labon-a-chip concept.	**15**

Reference Books:

1. Modern magnetic materials, Robert C. O'Handley, John Wiley & Sons Inc., 2000.
2. Introduction to magnetic materials, Cullity and Graham, John Wiley & Sons Inc., 2009.
3. Introduction to magnetism and magnetic materials, D. Jiles, Chapman and Hall pub., 1991.
4. Fundamentals of Magnetism, Mathias Getzlaff, Springer, 2008.
5. Spin Electronics, M. Ziese and M.Thornton (Eds.), Springer, 2001.
6. Advanced Magnetic Nanostructures, Sellmyer and Skomski (Eds.), Springer, 2006.
7. Introduction to Spintronics, S. Bandyopadhyay, M. Cahay, CRC Press, 2008.
8. Magnetoelectronics, M. Johnson, Academic Press 2004.
9. Advanced Magnetic Nanostructures, D. J. Sellmyer, R. Skomski, Springer, 2006.
10. Concepts in Spin Electronics, S. Maekawa, Oxford University Press, 2006.
11. 5. Spin Electronics, D.D. Awschalom, R.A. Buhrman, J.M. Daughton, S.V. Molnar, and M.L. Roukes, Kluwer Academic Publishers, 2004.

B. Sc. –M.Sc. in Nanoscience and Technology, (5 Years Integrated) Programme, Part – IV, Semester- VIII

Title of the Paper:- Statistical Mechanics and Nanothermodynamics

Sr. No.	Topics	No. of Lectures
Unit I	**Statistical Mechanics:** Partition function and its significance. Rotational, translational, vibrational and electronic partition functions. Use of spectroscopic data for evaluation of various partition functions. Relationship between partition function and thermodynamic properties. Calculation of equilibrium constant using Partition function.	**15**
Unit II	**Nanothermodynamics:** Thermodynamics and Nanothermodynamics, Fundamental equations of thermodynamics, equilibrium constant and reaction kinetics, non-equilibrium thermodynamics, Applications of Classical thermodynamics to Nanothermodynamics, Hill theory for small systems, modern thermodynamics, Nanothermodynamics of single molecule. Heat transport at low-dimensions.	**15**

Reference Books:

1. Introduction to Nanoscience and Nanotechnology. By Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore.
2. Statistical Physics of Nanoparticles in the Gas Phase, By Klavs Hansen · 2018 Springer International Publishing.
3. Elements of statistical thermodynamics - L. K. Nash, 2ndEd. Addison Wesley 1974.
4. Thermal Transport in Low Dimensions: From Statistical Physics to Nanoscale Heat Transfer,2016, Stefano Lepri, Springer International Publishing.
5. An Introduction to Statistical Thermodynamics – T. L. Hill, Addison-Wesley. 1960. 15. Statistical Mechanics – Donald A. McQuarrie, 2000.

NATURE OF QUESTION PAPER

All Questions are compulsory

Time duration (3 hours) **Total Marks: 80**

Q. 1. Select the correct answers: MCQ **1 x 8 = 8**

i) ii)

iii) iv)

v) vi)

vii) viii)

Q. 2. Write short notes on: **2 x 4 = 8**

a) b)

c) d)

Q. 3. Answer any six of the following: **4 x 6 = 24**

a)

b)

c)

d)

e)

f)

g)

h)

Q.4. Answer any five of the following: **8 x 5 = 40**

a)
b)
c)
d)
e)
f)

NATURE OF QUESTION PAPER

All Questions are compulsory

Time duration (1.5 hours) **Total Marks: 40**

Q. 1. Select the correct answers: MCQ **1 x 4 = 4**

i)

ii)

iii)

iv)

Q. 2. Write short notes on: **2 x 2 = 4**

a) b)

Q. 3. Answer any two of the following: **4 x 2 = 8**

a)

b)

c)

Q.4. Answer any three of the following: **8 x 3 = 24**

a)
b)
c)
d)