Syllabus for M.Sc. Nanoscience - 2017

	1st SEMESTER	
COURSE No.	**COURSE**	**CREDITS**
NS-601	Introduction to Nanoscience and Nanotechnology	4
NS-602	Surface,Colloid and Interface Science	4
NS-603	Introduction to Advance Biology	4
NS-604	Nanoscience and Environment	4
NS-605	Application of Computational Methods	3
NS-606	Synthesis of Nanomaterials	3
	Total	**22**
	2nd SEMESTER	
NS-607	Nanotechnology in Energy Conversion and Storage	4
NS-608	Nanosensors and Devices	4
NS-609	Nanostructured Materials and Processing	4
NS-610	Nanomaterials Synthesis and Characterization Techniques	4
NS-611	Nanomaterial Lab	2
NS-612	Seminar	2
	TOTAL	**20**
	3rd SEMESTER	
NS-701	Project Work	20
NS-702	Literature Review	10
	TOTAL	**30**
	4th SEMESTER	
NS-703	Supramolecular Chemistry and Biology	4
NS-704	Nanostructures in Biological Systems	4
NS-705	Carbon Nanostructures & Functionalization	4
NS-706	Organic and Inorganic Nanomaterials	4
NS-707	Comprehensive Viva	2
	TOTAL	**18**

1ST SEMESTER

NS-601	Introduction to Nanoscience and Nanotechnology	4

Unit I

Background to Nanoscience: Defination of Nano, Scientific revolution-Atomic Structure and atomic size, emergence and challengs of nanoscience and nanotechnology, carbon age-new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects and crystals, large surface to volume ration, surface effects on the properties.

Unit II

Types of nanostructure and properties of nanomaterials: One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots shell structures, metal oxides, semiconductors, composites, mechanical-physical-chemical properties.

Unit III

Application of Nanomaterial: Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, membrane based application, polymer based application.

References:

1. Chemistry of nanomaterials : Synthesis, properties and applications by CNR Rao et.al.
2. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
3. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831,Cambridge University Press.
4. Processing & properties of structural naonmaterials - Leon L. Shaw
   Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.

NS-602	Surface, Colloid and Interface Science	4

Unit I

Surface Nanoscience: Introduction to surface active agents. Theory and applications.Types of surfactants. Classification, synthesis of surfactant - Shape, size and structure of surfactants. Micelle, Emulsions, Microemulsions & Gels. Kraft temperature, surfactant geometry and packing.

Unit II

Colloidal Nanoscience:Introduction to colloidal material, surface properties, origin of colloidal particles, preparation & characterization of colloidal particles. Applications of super hydrophilic hydrophobic surfaces, self-cleaning surfaces.Surface viscosity.

Unit III

Nanoscience and Interface: Intermolecular Forces, Van der Waals forces (Kessorn, Debye, and London Interactions). Dynamic properties of interfaces. Contact angle. Brownian motion and Brownian Flocculation. Surface free energy.

References:

1. A.W. Adamson and A.P.Gast, *Physical Chemistry of surfaces*, Wiley Interscience, NY 2004.
2. P.C Hiemen and R.Rajgopalam, *Principle of colloid and surface Chemistry*, NY Marcel Dekker, 1997.

3. D.J.Shaw, *Colloid and surface chemistry*, Butterworth Heineman, Oxford,1992.
4. M. J. Rosen, *Surfactant and Interfacial phenomena*, Wiley Inter Science Publication, NY 2004.

NS-603	Introduction to Advance Biology	4

Unit I

Molecular Biochemistry: Biomolecular Structure and Stability. Biopolymers: DNA: structure, geometry, topology and modification, Proteins: enzymes and structural proteins; lipids: fatty acids, phospholipids, glycolipids, protein-lipid assembly and biomimetic nanostructures- lipid nanoparticles, polysaccharides: starch, cellulose, agar, agarose, pectin, xanthan. Mechanism of enzyme action: enzyme kinetics, enzyme regulation.Chemical transformation biomaterials.
Construction of Nanomachines, Protein Folding, Self-Assembly, Self-Organization, Molecular Recognition.

Unit II

Cell Biology: **Cell Biology**: Cell as unit of life. Tools and techniques. Prokaryotes and Eukaryotes cells- Structure and functions. Ultrastructure of plant, animal and microbial cells. Cell membranes & structures. Types of Cell division: Mitosis and Meiosis. Cell cycle and and its regulation. Cytoskeletal proteins.

Unit III

Molecular Biology: Biological nanomachines and genetic material: Nucleic acid structure; functional elements of DNA, Genome organization, DNA polymerases: DNA pol I , DNA pol II and DNA pol III, helicases- ligases- topoisomerases, recombinase- transposase - mitotic spindle and chromosome separation; RNA polymerases, RNA pol I , RNA pol II and RNA pol III.
DNA Templated Electronics, Single Biomolecule Manipulation for Bioelectronics, DNA as a semiconductor.

References:

1. Molecular Biology of the Cell, 5th Edition, Bruce Alberts.
2. Principles of Biochemistry, Nelson, Cox, Lehninger

NS-604	Nanoscience and Environment	4

Unit I

Environment Related Case Studies on Nanomaterials: Screening of nanomaterials for understanding potential effects to human health and the environment. Mapping of the environmental fate of nanomaterials. Relationships between key properties of nanomaterials and their environmental fate, transport, transformation, bio-distribution, toxicity.

Unit II

Environmental Pollution by Nanoparticles: Health impact, safety and toxicological effects transport of nanomaterials in soil/sediments. Study of physical and chemical properties of nanomaterials influencing their behavior in the environment and in biological systems.

Unit III

Application to Environment: Nanotechnology for waste reduction and improved energy efficiency, nanotechnology based water treatment strategies. Nanoporous polymers and their applications in water purification, Nanotoxicology.

References:

1. Environmental Chemistry for a Sustainable World, Volume 1: Nanotechnology and Health Risk Editors: Lichtfouse, Schwarzbauer, Robert
2. Advances in Nanotechnology and the Environment, Juyoung Kim, CRC Press, Taylor and Francis Group.

NS-605	Application of Computational Methods	4

1. Development of chemical library and screening of promising compounds using computer assisted drug design (CADD) techniques.
2. Simulation of nanocomposite and analysis using molecular dynamic (MD) simulation.
3. Encapsulation of nanoparticle and interaction studies using molecular simulation.
4. Isolation of DNA and separation using Gel electrophoresis.
5. Isolation of protein and separation using Gel electrophoresis.
6. Interaction of ligand-protein, protein-protein, protein-DNA using molecular simulation.

NS-606	Synthesis of Nanomaterials	4

1. Synthesis of Metal Oxide Nanoparticle.
2. Characterisations using UV visible spectrophotometer, FTIR, X-ray Ananysis.
3. Synthesis of Polymeric Nanocomposite.

2ND SEMESTER

NS-607	Nanotechnology in Energy Conversion and Storage	4

Unit I

Renewable Energy: Energy conversion process. Introduction to Semiconductor physics, Conducting and semiconducting materials, Semiconductor nanostructures, Electronic structure and physical process, material aspect of solar cells, Thin film solar cells, Solar cell characteristics and characterization techniques.Nano-, micro-, and poly crystalline and amorphous Si for solar cells, Si deposition techniques.

Unit II

Plastic/flexible solar cells: Organic solar cells, Polymer composites for solar cells, p-n junction, Device fabrication and characterization, Nanomaterials for solar cells, Dye-sensitized solar cells, Organic-inorganic hybrid solar cells, Current status and future prospects.

Unit III

Fuel Cells: Polymer membranes for fuel cells, Acid/ alkaline fuel cells, design of fuel cells, Carbon Nanotubes for energy storage, Hydrogen Storage in Carbon Nanotubes, Use of nanoscale catalysts to save energy and increase the industrial productivity.

References:

1. Solar cells: Operating principles, technology and system applications by Martin A Green,Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
2. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993.
3. Solis state electronic device, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995.
4. Organic Photovoltaics – Materials, Device Physics and Manufacturing Technologies, (eds. C. Brabec, V. Dyakonov, U. Scherf), 2nd Ed., Wiley-VCH, Germany, 2014.
5. Hand book of Batteries and fuel cells, Linden, McGraw Hill, 1984.

NS-608	Nanosensors and Devices	4

Unit I

Nanosensors: Introduction to sensors. Characteristics and terminology - static and dynamic characteristics.Micro and nano-sensors, Fundamentals of sensors, biosensor, micro fluids, Packaging and characterization of sensors, Sensors for aerospace and defense.
Organic and inorganic nanosensors.

Unit II

Nanotechnology enabled devices: Nanomaterials and nanostructured films,Nanoscale electronic and ionic transport.Sensor for bio-medical applications.Nanoparticle-biomaterial hybrid systems for sensing applications.Gas sensor.

Unit III

Biosensors: Magnetic Nanoparticles for Imaging and Therapy, Photodetectors, Nanophotonics. Nanoelectronic Devices. Biosensors, Clinical diagnostics, generation of biosensors. Nanomaterial based biosensors. Biosensors based on nucleotides and DNA.Electron transfer of biomolecules.

References

1. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester, 2002.
2. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
3. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
4. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.

NS-609	Nanostructured Materials and Processing	4

Unit I

Synthesis and preparation of Nanomaterials: Synthesis of bulk nanostructured materials - Sol Gel processing- bulk and nano composite materials - Grinding - high energy ball milling – injection moulding - extrusion - melt quenching and annealing.

Unit II

Synthetic Technique (Physical and Chemical): Self assembly-Self Assembled Monolayers (SAM) - Vapour Liquid Solid (VLS) approach - Chemical Vapour Deposition (CVD) - Langmuir-Blodgett (LB) films - Spin coating - Templated self assembly Electrochemical approaches: Thin films -Epitaxy -Lithography.

Unit III

One dimensional and Two dimensional nanostructures: Nanowires and Nanotubes: Evaporation-condensation - Vapor- liquid - solid (VLS) - surface and bulk diffusion – kinetics – growth of various nanowires –control of size –precursors and catalysts - single- and multi-wall CNT - Si nanowires – density and diameter – doping in nanowires

References:

1. W. Gaddand, D.Brenner, S.Lysherski and G.J.Infrate (Eds), Handbook of nanoscience, Engg and Technology, CRC Press,2002.
2. G.Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, 2004.
3. J.George, Preparation of thin films, Marcel Dekker, InC., New York, 2005.

4. C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH Verlag Gmbh&Co, Weinheim, 2004.

NS-610	Nanomaterials Synthesis and Characterization Techniques	4

Unit I

Synthesis and preparation of Nanomaterials: Synthesis of bulk nanostructured materials - Sol Gel processing- bulk and nano composite materials - Grinding - high energy ball milling – injection moulding - extrusion - melt quenching and annealing.

Unit II

Synthetic Technique (Physical and Chemical): Self assembly-Self Assembled Monolayers (SAM) - Vapour Liquid Solid (VLS) approach - Chemical Vapour Deposition (CVD) - Langmuir-Blodgett (LB) films - Spin coating - Templated self assembly Electrochemical approaches: Thin films -Epitaxy -Lithography.

Unit III

One dimensional and Two dimensional nanostructures: Nanowires and Nanotubes: Evaporation-condensation - Vapor- liquid - solid (VLS) - surface and bulk diffusion – kinetics – growth of various nanowires –control of size –precursors and catalysts - single- and multi-wall CNT - Si nanowires – density and diameter – doping in nanowires

References:

1. W. Gaddand, D. Brenner, S. Lysherski and G. J. Infrate (Eds), Handbook of nanoscience, Engg. and Technology, CRC Press, 2002.
2. G. Cao, Naostructures and Nanomaterials: Synthesis, properties and applications, Imperical College Press, 2004.
3. J. George, Preparation of thin films, Marcel Dekker, InC., New York, 2005.
4. C. N. R. Rao, A. Muller, A. K. Cheetham (Eds), The chemistry of nanomaterials: Synthesis, properties and applications, Wiley VCH Verlag Gmbh & Co, Weinheim, 2004.

NS-611	Nanomaterial Laboratory	2

1. Synthesis of Nanoferroelectric materials.
2. Synthesis of Ag and Au nanoparticles and their characterizations

NS-612	Seminar	2

Each candidate shall present a seminar on recent topics in a departmental seminar during a period not exceeding 15 minutes. Performance of the candidates in the seminar shall be evaluated jointly by Examiners.

3RD SEMESTER

NS-701	Project Work	20

Each candidate shall carry out some investigative research work under the supervision of one or more mentor(s), who may be Teacher/Guest Teacher of University/Scientist of any recognized research institute. The work may be carried out either in the University itself or in any

recognized research institute, with the approval of the appropriate authority of the University. Duration of the work shall be eight weeks (approximately 200 hours). The findings of the project work should be submitted in the form of a dissertation for evaluation by a Board of Examiners followed by a presentation through a seminar.

NS-702	Literature Review	20

The candidates shall carry out review work on literatures published in the last five years on a special topics assigned to them by the guide. They can also choose a topic of their choice and approved by the guide. They should submit the review to the course coordinator and the performance of the candidates shall be evaluated by the committee including the guide.

4TH SEMESTER

NS-703	Supramolecular Chemistry of Nanomaterials	4

Unit I

Supramolecular aspects in Chemistry: Fundamental understanding, Host-guest complexation chemistry, micelles, polymers, cyclodextrins, functionalization reactions, Introduction to supramolecular catalysis and enzymes, Multifunctional catalysis and simple models, Hydrolytic enzymes.

Unit II

Supramolecular aspects of Biological Systems: Introduction, Host-guest complexation in molecular biology, DNAs, proteins and enzymes, synthetic molecular receptors, Receptors with molecular theft, Molecular tweezers, Receptor with multiple H- bonding sites, enantioselective molecular recognition, molecular recognition and catalysis, molecular self-assembly, Templating agents in biological systems.

Unit III

Host-Guest Complexation: Introduction, Nature of supramolecular interactions, Type of host-guest complexes, Structure of complexes, Comparison of structures of non-complexed and complexed hosts, Detail structural comparisons, Correlation of structure with free energies of complexation. Supramolecular devices and nanotechnology.

References:

1. Supramolecular Chemistry from Molecules to Nanomaterials, Gale and Steed, 2012.
2. Modern Supramolecular Chemistry, Diederich, Stang, Tykwinski, 2008.
3. Principles of Biochemistry, Nelson, Cox, Lehninger

NS-704	Nanostructures in Biological Systems	4

UNIT I

Nucleic Acid : Genome structure and organization in prokaryotes and eukaryotes. Structure and function of nucleic acids. Replication, transcription and translation- mechanism, enzymology and regulation. Applications of nanoscience in biological systems - drug targeting, drug delivery and biomedicine.

UNIT II

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

UNIT III

Carbohydrates and lipids: Classification, Nomenclature, Structure, Function of carbohydrates and lipids. Membrane transport. Metabolism and energy production. Integrative metabolism of biomolecules, Electron transport chain, oxidative phosphorylation, energy production.

References:

1. R. Cantor, P.R.Samuel, ―Biophysical Chemistry, W.H., Freeman & Co., 1985.
2. Watson, James, T. Baker, S. Bell, A. Gann, M. Levine, and R. Losick ―Molecular Biology of the Gene‖, 5th ed., San Francisco: Addison-Wesley, 2000.
3. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell. 4th ed. New York: Garland Science, 2002.

NS-705	Carbon Nanostructures & Functionalization	4

Unit I

Carbon nanotube (CNT) and its Applications: Carbon nanotube (CNT), structure of CNT, synthesis and functionalization of CNT, electronic, vibrational, mechanical and optical properties of CNT; applications of CNT and Fullerenes.

Unit II

Graphene and its Functionalization: Graphene, structure of Graphene, synthesis and functionalization of Graphene, electronic application of Graphene, Electrochemical deposition, Graphene Oxide.

Unit III

Carbon Nanomaterials for Environment and Biology: Carbon nano-adsorbents, Carbon Based Nanomaterials and its Environmental Effects, Biological aspects of Carbon Nanostructures, Fullerene and its derivatives.

Refrences:

1. Intoduction to Nanotechnology- Charles P Poole & Frank J. Ownes.
2. Physical properties of Carbon Nanotube-R Satio
3. Applied Physics Of Carbon Nanotubes : Fundamentals Of Theory, Optics And Transport Devices - S. Subramony & S.V. Rotkins
4. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell
5. Nanotubes and Nanowires- CNR Rao and A Govindaraj RCS Publishing 10. Nanoscale materials -Liz Marzan and Kamat
6. Carbon Nanomaterials for Environmental and Biological Applications, Bergmann and Machado., Springer.

NS-706	Organic and Inorganic Nanomaterials	4

UNIT I

Nanostructured Magnetism: Nanostructure magnetism, Effect Bulk nanostructuring of magnetic property, Giant and colossal magnetic resistance, Nanomagnetic materials, Paramagnetism in metallic nanoparticles, Semiconduction quantum dots.

UNIT II

Thermoelectric Materials: Concept of phonon, Thermal conductivity specific heat, exothermic and endothermic processes, Different types of thermoelectric materials, Bulk properties, One dimensional and composite thermoelectric materials, Applications.

UNIT III

Structure Properties of Polymeric Nanomaterials and Applications: Structure-property relationship, stress-strain behaviour, crystalline melting point, effect of chain flexibility and other steric factors, entropy and heat of fusion, glass transition temperature, relationship between Tm and Tg. Effect of molecular weight, property requirements and its utilization. Synthetic procedure commercial polymers, Fire retarding and biomedical polymers.

References

1. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993.
2. Solis state electronic device, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995.
3. Organic Photovoltaics – Materials, Device Physics and Manufacturing Technologies, (eds. C. Brabec, V. Dyakonov, U. Scherf), 2nd Ed., Wiley-VCH, Germany, 2014.
4. Text Book of Polymer Science, F.W. Billmeyer Jr, Wiley.
5. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.

NS-707	Comprehensive Viva	2

Comprehensive viva-voce examination shall be conducted jointly by the external and internal Examiners. Short questions on the theoretical principles, experimental methodologies and instrumentations etc. of the different experiments included in the entire practical/project syllabus of semesters-I, -II, -III and -IV may be asked, Maximum time for viva-voce examination of a candidate shall not normally exceed 15 minutes.