Syllabus

(1st and 2nd semester)

M.Sc. in Nanoscience and Nanotechnology

Choice Based Credit System (CBCS)

School of Interdisciplinary Studies
University of Kalyani
(2019 onwards)

Course Name

M.Sc. in **Nanoscience and Nanotechnology**

About the course

On December 29, 1959, in his classic lecture at the annual meeting of the American Physical Society at Caltech, Richard Feynman said

"*I would like to describe a field, in which little has been done, but in which an enormous amount can be done in principle……..Furthermore, a point that is most important is that it would have an enormous number of technical applications…… there is plenty of room at the bottom*"

He invited the audience to enter and venture this new field of physics. Within a couple of decades, the term nanotechnology was coined and remarkable advancement and novel discoveries in this new 'world of nano' followed.

Nanoscience and Nanotechnology deals with understanding and manipulating of matter at dimensions of approximately 100 nm and below, with cross sectoral application and an interdisciplinary orientation. Within nanoscale, the physical, chemical and biological properties of materials differ from the properties of individual atoms and molecules or bulk matter enabling novel applications. Definition of nanotechnology is naturally very broad and includes various fields of science such as quantum mechanics, surface science, organic chemistry, molecular biology, semiconductor physics, nanofabrication, etc. The programme on nanoscience and nanotechnology aims to provide a multidisciplinary natural science education towards students from various backgrounds with physics, chemistry, mathematics and biological sciences. This science of miniscule encompasses a wide area of research ranging from energy and environmental applications to cancer treatment and targeted drug delivery.

Globally acclaimed Universities and Institutions have already started post graduate programme in Nanoscience and nanotechnology for better understanding the roles of nanomaterial in optical technology, medical science, space science, pharmaceuticals, biotechnology etc. However, in India, only a few educational institutions/ Universities offer this kind of advanced course. Introducing the M.Sc. program in **Nanoscience and Nanotechnology** is a first-of-its-kind initiative in Eastern and North-Eastern India.

The program on **Nanoscience and Nanotechnology** will enhance the knowledge and skill of the students from a wide range of backgrounds. The program consists of flexible and modular course structure and includes full-time M.Sc. course, delivered over two years. The M.Sc. program will be structured on semester system (having 4 semesters), so that all modules become available at least once in each 12 months. This program aims to enhance knowledge and skill development in this fast evolving discipline by providing a flexible, interdisciplinary course in nanoscience and nanotechnology as both basic and applied level to different stakeholders.

Objective

Human Resource Development with wide, cutting-edge and in-depth knowledge in nanoscience and nanotechnology with the ability to translate in the benefit of the society.

Evaluation

Continuous evaluation based on specific components such as Tests, seminars, assignments/quiz carries 20% weightage and end semester examination carries 80% weightage. For laboratory courses, end semester examination carries 70% weightage and continuous assessment carries 30% weightage. Overall performance of the student will be indicated in Grades.

Course Credits

Minimum credit required for successful completion of the program is **80 credits** including that of core courses, Elective Courses and Dissertation

Duration

The duration of the course is two years, covering four semesters.

Highlights of the course

❖ Two year-four semesters self-financed CBCS curriculum-based M.Sc. Program.

❖ Extensive on-the-bench training utilising state-of-the-art instrumentation facility of the University of Kalyani.

❖ Cyber classes by renowned faculties from nationally and internationally acclaimed Universities/Institutes.

❖ Internship programmes in reputed Institutes/universities in India and abroad.

❖ Interaction with reputed company personnel in the field and encouraging entrepreneurship programme.

❖ Job opportunities in the fields of nanotechnology and biotechnology Industries, Pharmaceutical Industries, Instrument manufacturing companies, Agricultural Industries and Educational Institutions, Health Care.

M. Sc. course in Nanoscience & Nanotechnology, University of Kalyani

1st Semester:

A		Theory			
Sl. No.	**Course Code**	**Course Title**	**Hrs/Wk [L-T-P]**	**Credit**	**Points**
1	NST101	Foundations of Nanoscience	3-1-0	4	100
2	NST102	Synthesis of Nanomaterials	3-1-0	4	100
3	NST103	Characterization of Nanomaterials	3-1-0	4	100
4	NST104	Biology for Nanoscience	3-1-0	4	100
		Total Theory	**12-4-0**	**16**	**400**
B		**Practical**			
5	NSP111	Nanotechnology Lab-I	0-0-9	3	75
6	NSP112	Biology Lab-I	0-0-6	2	50
7	NSP113	Biostatistics & Computing Lab - I	0-0-6	2	50
		Total Practical	**0-0-21**	**7**	**175**
C		**Sessional**			
8	LSS121	Communicative English & HR management - I	0-0-3	1	25
		Total Sessional	**0-0-3**	**1**	**25**
		Semester Total	**12-4-24**	**24**	**600**

2nd Semester:

A		Theory			
Sl. No.	**Code**	**Course Title**	**Hrs/Wk [L-T-P]**	**Credit**	**Points**
1	NSTO201	Fundamentals of Nanoscience and Nanotechnology	3-1-0	4	100
2	NST202	Aspects of Nanotechnology	3-1-0	4	100
3	NST203	Computational Nanoscience	3-1-0	4	100
4	NST204	Nanotechnology in Medical Science	3-1-0	4	100
		Total Theory	**12-4-0**	**16**	**400**
B		**Practical**			
5	NSP211	Nanotechnology Lab-II	0-0-9	3	75
6	NSP212	Biology Lab-II	0-0-6	2	50
7	NSP213	Computational Nanoscience Lab	0-0-6	2	50
		Total Practical	**0-0-21**	**7**	**175**
C		**Sessional**			
8	LSS221	Communicative English & HR management - II	0-0-3	1	25
		Total Sessional	**0-0-3**	**1**	**25**
		Semester Total	**12-4-24**	**24**	**600**

Details of abbreviated paper codes

NST Nano Science Theory

NSP Nano Science Practical

NSS Nano Science Sessional

NSTO Nano Science Theory (Open Choice)

NSE Nano Science Elective

1st Digit in the Suffix No. of Semester [1= Semester I, 2= Semester II, 3= Semester III, 4= Semester IV]

2nd Digit in the Suffix Type of paper [0 = Theory paper; 1 = Practical paper; 2 = Sessional Paper]

3rd Digit in the Suffix No. of paper [1 = 1st paper; 2 = 2nd paper; 3 = 3rd paper; 4 = 4th paper]

NST101 - Foundations of Nanoscience

[L-T-P = 3-1-0] Credit: 4

Module - I [8L]

Chronological development of nanoscience and nanotechnology (NSNT). Important discoveries in NSNT. Idea about dimension – Light year to atomic scale. Introduction to nanostructures. Glimpse of various applications of NSNT.

Module - II [8L]

Basics of molecular spectroscopy. Idea about spectra- FWHM, Fourier transformation, Signal to Noise ratio- Natural broadening- Doppler Broadening- Homogeneous broadening. Idea about rotational and vibrational spectroscopy- Idea about spectra of different nanostructures.

Module - III [8L]

Basics of quantum mechanics. Limitations of classical mechanics, introduction to quantum mechanics, contributions of Heisenberg, Dirac, and Schrodinger. concept of de Broglie wave, interpretation of wave equation, postulates of quantum mechanics, operators, eigen function, particle in a box, harmonic oscillator, Born – Oppenheimer approximation, hydrogen atom, uncertainty principle, photoelectric effect, applications of quantum mechanics in NSNT.

Module - IV [8L]

Solid state chemistry and crystal structure elucidation: Basics of crystal structure. Examples of crystals, concept of reciprocal lattice, electronic properties of solids, conductor, semiconductor and insulator. Fermi level and shift of Fermi level and change in electrode potential values for understanding redox reaction. Band structures in nanomaterials- alloy and composites, core-shell (including hollow core) structures, metallic- polymeric- metal oxide.

Module - V [8L]

Basics of optics, basic principle of microscopy, plasmonics, nanospectroscopy, nanooptics, photonic crystal.

Reference books:

1. Introduction to nanoscience and nanotechnology. Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore
2. Basic principles of nanotechnology. Wesley C. Sanders
3. Introduction of quantum mechanics. D. J. Griffiths

4. Quantum Mechanics. C. J. Joachain, B. H. Bransden
5. Fundamentals of Optics. Harvey Elliott White, Francis Jenkins
6. Optical properties of metal clusters. Uwe Kreibig, Michael Vollmer
7. Principles of nano-optics. Lukas Novotny, Bert Hecht
8. Introduction of electrodynamics. D. J. Griffiths
9. Laser fundamentals. William T. Silfvast
10. Molecular spectroscopy. G. M. Barrow
11. Introduction to nanoscience and nanotechnology. K. K. Chattopadhyay, A.N. Banerjee
12. Physical chemistry - Peter Atkins, Julio de Paula, 7th Edition Oxford University Press.
13. Optical Properties of Metal Clusters by U. Kreibig and Michael Vollmer (Springer)

NST102 - Synthesis of Nanomaterials

[L-T-P = 3-1-0] Credit: 4

Module - I [8L]

Chemical methods I: Synthesis of semiconductor nanoparticles, nanowires, quantum dots, nanoclusters, metal oxide nanoparticles- ZnO,TiO2.

Module - II [8L]

Module - II [8L] Chemical methods II: Metal nanoparticle by reduction, Nanoparticle synthesis of different types of metals (Cu, Ag, Au, Pd, Pt), synthesis of nanoparticles having different size, shapes and facet selective synthesis.

Module - III [8L]

Top down methods: Lithography, Electron beam lithography, Ion beam lithography, X-ray lithography, UV lithography, Synthesis of nanomaterials by Laser ablation- chemical vapour deposition- Molecular beam epitaxy

Module - IV [8L]

Nanopolymer, carbon based nanostructures - carbon nanotube, graphene, fullerenes.

Module - V [8L]

Biological methods of nanoparticle synthesis by bacteria, fungi, algae, plants, mechanism of formation, use of viruses as components of nanostructured materials, electrospinning of nanofibres, green synthesis of nanoparticles, biomaterial-based metallic nanowires.

Reference books:

1. Nano Materials Synthesis and Characterisation. V. Rajendran
2. Understanding nanomaterials. Malkiat S. Johal, Lewis E. Johnson

3. Nanoparticles: Building Blocks for Nanotechnology. Vincent Rotello
4. Edelestein A.S and Cammarata RC, Nano materials synthesis, properties and applications
5. Nicholas A. Kotov, Nanoparticle Assemblies and Superstructures‖, CRC, (2006)
6. Guozhong Cao, Nanostructures & Nanomaterials Synthesis, Properties G; Z, Applications, World Scientific Publishing Pvt. Ltd., Singapore 2004
7. Nanotechnology-An Introduction to Nanostructuring Techniques by Michael Kohler, Wolfgang Fritzsche, Michael Kohler, Wolfgang Fritzsche, Wiley (Practical)

NST103 - Characterization of Nanomaterials

[L-T-P = 3-1-0] Credit: 4

Module - I [8L]

Spectral characterization: Absorption, Emission , Circular Dichroism Spectroscopy (CD), Optical Rotatory Dispersion (ORD)- InfraRed (IR)- Raman spectroscopy and Surface Enhanced Raman Spectroscopy (SERS)-Electron energy loss spectroscopy (EELS)-Photoelectron spectroscopy (PES), X-Ray Photoelectron Spectroscopy (XPS)

Module - II [8L]

Structural characterization: X-ray diffraction- Transmission electron microscopy (TEM)- Scanning electron microscopy (SEM)-Selected Area Diffraction (SAED) -Energy dispersive X-ray spectroscopy (EDAX)

Module - III [8L]

Surface characterization: Scanning tunneling microscope (STM)- Atomic force microscopy (AFM) - Scanning transmission electron microscopy (STEM)- High-angle annular dark-field microscopy (HAADF)

Module - IV [8L]

Magnetic characterization: Nuclear Magnetic Resonance Spectroscopy (NMR), Magnetic Force Microscopy (MFM), Superconducting quantum interference device (SQUID).

Module - V [8L]

Mechanical-Thermal-Electrical Characterization of nanomaterials, Imaging- Confocal, Dark field scattering

Reference books:

1. Transmission Electron Microscopy: A Textbook for Materials Science. C. Barry Carter and David B. Williams

2. Elements of X-ray diffraction.B. D. Cullity
3. Scanning Electron Microscopy: Physics of Image Formation and Microanalysis. Ludwig Reimer
4. Introduction to Scanning Tunneling Microscopy. C. Julian Chen
5. Confocal Microscopy for Biologists. Alan R. Hibbs
6. Principles of Three Dimensional Imaging in Confocal Microscopes. Min Gu
7. Confocal Microscopy. Jian Liu and Jiubin Tan
8. Confocal Raman Microscopy. Thomas Dieing, Jan Toporski, Olaf Hollricher
9. Dark-field Microscopy. John A. Allocca
10. Magnetic Microscopy of Nanostructures. Herbert Hopster, Hans Peter Oepen

NST104 - Biology for Nanoscience

[L-T-P = 3-1-0] Credit: 4

Module - I [8L]

Structure and function of biomolecules/molecules, carbohydrates, proteins, lipids, nucleic acids.

Module - II [8L]

Cell as a factory, Biological nanomotors and machines, mechanisms of biological machines, Genome organization, DNA polymerases, ligases, topoisomerases, gyrases, mitotic spindle and chromosome separation; RNA polymerases, protein assemblies: muscle myosin, kinesin, nerve, ATPase, bacteriorhodopsin, haemoglobin dynein, cilia. Bacterial flagella: structure and function; nanomotor. Ion channels: nanopores of high specificity.

Module - III [8L]

Cell signaling, cell-cell communication, central dogma. Signal transduction and cytoskeleton-Regulation of programmed cell death, apoptosis and autophagy. Innate immunity- adaptive immunity-cells of reticulo endothelial system

Module - IV [8L]

Biological nanoparticles and their applications. Exosomes, lipoproteins, ferritin, magnetite viruses. Bioinspired nanomaterials: DNA and peptide based. Interaction between biomolecules and nanoparticle surfaces. Use of DNA and proteins as actuators, chips, sensors and electronic circuits.

Module - V [8L]

Biostatistics: Statistics of dispersion: Variability, Range, Mean, Mode, Mean deviation, Standard Deviation, Variance, central moments, Coefficient of Quartile deviation, Coefficient of variation, Coefficient of dispersion; **Probability Distribution:** Probability mass function for discrete random variables and probability density function for continuous random variables; Skewness, Kurtosis; **Testing of Hypothesis:** Concepts and importance in experimental research, type of errors; testing

means, Significance of difference between means using Z-score; Large sample tests based on normal distribution – Test based on t and F distributions, Chi square test for goodness of fit, Correlation and Regression: Multiple correlation, Linear, logistic, and multiple regression; **Multivariate Methods:** PCA, MDS; cluster analysis; factor analysis; **Non-parametric and distribution-free statistics:** Sign test, Wilcoxon's rank test and Spearman's rank correlation; MDR analysis, **Analysis of Variance:** One way and two way classifications of Anova, Post-hoc analysis, ROC curve analysis – applications in Biological Sciences.

Reference books:

1. Molecular Biology of the Cell, 5th Edition, Bruce Alberts.
2. Principles of Biochemistry, Nelson, Cox, Lehninger
3. Cell Biology, T.W. Kimball
4. Cell and Molecular Biology, H Baltimore, W H Freeman.
5. Immunology, Janis Kuby.
6. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
7. The Cell A Molecular Approach; 2nd Edition, by Geoffrey M. Copper, ASM press, Sinauer Associates, Inc., Washington, (2000)
8. Introduction to Biostatistics- Pranab K Banerjee. (S. Chand & Co.)
9. Biostatistics- P.N. Arora, P.K. Malhan (Himalaya Publishing House)
10. Statistics in Biology and Psychology- Debajyoti Das and Arati Das (Academic Publishers)

NSP111 - Nanotechnology Lab-I

[L-T-P = 0-0-9] Credit: 3

1. Synthesis of nanoparticles (silver,gold) and analysis of localized surface plasmon resonance (LSPR).
2. Analysis of Temporal stability of nanoparticles.
3. Scanning electron microscopy and Energy dispersive X-ray spectroscopy (EDAX) of nanoparticles: Sample preparation and analysis
4. Dynamic light scattering study of nanoparticles: Sample preparation and analysis characterization.
5. Atomic force microscopy of nanoparticles: Sample preparation and analysis
6. Synthesis of super paramagnetic nanomaterials - iron oxide/ nickel oxide
7. Synthesis of semiconductor nanoparticles and characterization (CdS)

NSP112 - Biology Lab-I

[L-T-P = 0-0-6] **Credit: 2**

Basic Biochemistry Experiments

1. Quantitative analysis of amino acids
2. Protein estimation by Lowry/Bradford method
3. Total sugar estimation by phenol-sulphuric acid reagent method
4. Estimation of reducing sugar from biological sample
5. pH metric titration of glycine for determination of pI
6. Ascorbic acid estimation from lemon juice
7. Chromatography techniques.

Basic Molecular Biology Experiments

1. Isolation of DNA from different sources (Buccal swab, blood, animal & plant tissue)
2. Agarose gel electrophoresis
3. Quantitative & qualitative analysis of nucleic acid (NanoDrop, Qubit)
4. Polymerase chain reaction: general

NSP113 - Biostatistics & computing Lab - I

[L-T-P =0-0-6] **Credit: 2**

1. Introduction to C, R, SPSS, MS Excel for statistical analysis
2. Primer designing: Primer3, Oligocalc, SMS2, BLAST
3. Handling of Databases: NCBI, BOLD etc.
4. Structure-Prediction of Biomolecules with applications in Bioinformatics

NSTO201 - Open Choice (CBCS course)

Fundamentals of Nanoscience and Nanotechnology

[L-T-P = 3-1-0] Credit: 4

Module - I [10L]

Basics of Nanoscience and Nanotechnology

Chronological development of nanoscience and nanotechnology (NSNT). Important discoveries in NSNT. Idea about dimension – Light year to atomic scale. Basics of molecular spectroscopy. Basics of quantum mechanics. Atomic structure, band structure.

Module - II [10L]

Introduction to Nanomaterials

Different types of nanomaterials: Metallic- Polymeric- Carbon- Metal Oxide- Core Shell. Overview on nanomaterial synthesis- physical, chemical and biological methods. Properties of nanomaterials- mechanical, electrical and optical.

Module - III [10L]

Tools and techniques of Nanoscience and Nanotechnology

Spectral characterization: Absorption- Emission- Infra Red (IR) - Raman spectroscopy; X-ray diffraction; Structural characterization:- TEM- SEM; Surface characterization: STM- AFM.

Module - IV [10L]

Applications of Nanoscience and Nanotechnology

Energy conservation and storage, Nanoelectronic devices, semiconductor nanodevices, solar cells, environmental remediation through nanoparticles, Nanoporous polymers and their applications in water purification, Biomedical Nanotechnology, Nanotechnology in Agriculture - Precision farming, Nanofertilizers-Nanourea and mixed fertilizers, Nanopesticides, Nanoseed Science. Nanotechnology in Food industry – Nanopackaging for enhanced shelf life.

NST202 - Aspects of Nanotechnology

[L-T-P = 3-1-0] Credit: 4

Module - I [8L]

Energy conservation: 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. 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.

Module - II [8L]

Nanoelectronics: Fundamentals of Nano-Electronics & Nano-fabrication; Molecular electronics and basic properties of molecular materials; Optical & electron beam lithography, Molecular beam lithography. MEMS and NEMS: Development of microelectronics - Region of Nanostructures - methods and limits on microminiaturization in semiconductors- micro electro mechanical systems.

Module - III [8L]

Environmental Remediation through nanoparticles-Nano Membranes, Nano Meshes, Nano Fibres, Nano Clays and Adsorbents, Zeolites, Nano Catalysts, Carbon Nano Tubes. Nanotechnology for waste reduction and improved energy efficiency, nanotechnology based water treatment strategies. Nanoporous polymers and their applications in water purification. 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

Module - IV [8L]

Nanotechnology in Agriculture - Precision farming, Smart delivery system – Nanofertilizers: Nanourea and mixed fertilizers, Nanopesticides, Nanoseed Science. Nanotechnology in Food industry – Nanopackaging for enhanced shelf life - Smart/Intelligent packaging - Food processing and food safety and bio-security – Electrochemical sensors for food analysis and contaminant detection.

Module - V [8L]

Nanocatalysis

Nanocatalysis 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, heterogeneous, carbonaceous and plasmonic photocatalysts. Importance of facet selective catalysis including defects (stacks, steps and kinks in nanocatalyst)

Reference books:

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. Organic Photovoltaics – Materials, Device Physics and Manufacturing Technologies, (eds. C. Brabec, V. Dyakonov, U. Scherf), 2nd Ed., Wiley-VCH, Germany, 2014.
4. Nanotechnology and Nanoelectronics: Materials, Devices, Measurement Techniques, by W.R. Fahrner, Springer, 2005.
5. Nanoelectronic and Nanosystems:From Transistors to Molecular Quantum Devices, K. Goser, P.Glosekotter & J. Dienstuhl, Springer, 2004.
6. "MEMS and NEMS: Systems, Devices and Structures", by S. E. Lyshevski, CRC Press, 2002.
7. Environanotechnology by Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, Rachid Sliman, Ian Wright. Elsevier, 2010.
8. Nanotechnology in agriculture and food production by Jennifer Kuzma and Peter VerHage, Woodrow Wilson International Center, (2006).
9. Nick Serpone and Ezio Pelizzetti, Photocatalysis: Fundamentals and Application, Wiley Interscience, 1st Edition, 1989
10. Photoelectrochemistry, Photocatalysis and Photoreactors Fundamentals and Developments, Schiavello, Mario (Ed.) Springer, 1985.
11. Surface and Nanomolecular Catalysis Edited by Ryan Richard (CRC) Taylor and Francis

NST203- Computational Nanoscience

[L-T-P = 3-1-0] Credit: 4

Module - I [8L]

Numerical Methods I: Importance of numerical methods in nanoscience, Finite element method (FEM), Boundary element method (BEM)

Module - II [8L]

Numerical Methods II: Finite difference time domain (FDTD), Finite integration technique (FIT). Discrete dipole approximation (DDA)

Module - III [8L]

Introduction to computational biology, Biological sequence analysis, gene finding, comparative genomics, RNA structure, sequence alignment, hashing, biochemical network analysis, Hidden Markov models, Markov Chain Monte Carlo. Gene expression, clustering/ classification, expectation maximization (EM) / Gibbs sampling, motifs, Bayesian networks, microRNAs, regulatory genomics,

epigenomics. Nanoinformatics: information technology in bioinformatics, computational chemistry and nanobiotechnology.

Module - IV [8L]

Modelling and applications in nanobiology: Introduction to the structural hierarchy in nucleic acid structure and proteins. Explanation of various interactions determining the structures of biomolecules, features and importance of hydrogen bonding in biomolecules. Introduction to basic statistical mechanical theory and quantum theory, excited state and ground state analysis, energy minimization, single point calculation and transition state calculations. Basic computations with reference to simple chemical and biological molecules. Dynamics of chemical and biological molecules. Introduction to computer simulation methods, molecular dynamics simulation, examples with reference to simple molecules

Module - V [8L]

Introduction to big data analysis: Introduction, distributed file system, Big Data and its importance, Drivers, Big data analytics, Big data applications. Algorithms, Matrix-Vector, Multiplication by Map Reduce; Data visualization

Reference:

1. Essential Bioinformatics- JinXiong, (Oxford University Press)
2. Bioinformatics: Sequence and Genome Analysis- David W. Mount. (CSHL Press).
3. Bioinformatics and Functional Genomics- Jonathan Pevsner, (Wiley-Liss)
4. Structural Bioinformatics- P. E. Bourne and H. Weissig. (Wiley)
5. Introduction to Bioinformatics- Arthur W. Lesk (Oxford University Press.)
6. Guidebook on Molecular Modeling in Drug Design-N. R. Cohen, Editor. (Academic Press.)
7. Introduction to Protein Structure-C. Branden and J. Tooze (Garland Publishing)
8. Molecular Modelling: Principles and Applications-Andrew Leach (Pearson Education)
9. Drug Discovery and Design-Scolnick. J., (Academic Press, London)
10. Bioinformatics-Principles and Applications-Z.Ghosh and B. Mallick (Oxford University Press)
11. Introduction to Computational Biology: Maps, Sequences and Genomes-Michael S. Waterman (Chapman and Hall/CRC)
12. Computational electrodynamics- Allen Taflove (Artech House)
13. The Finite Element Method in Electromagnetics- Jian-Ming Jin (Wiley-IEEE Press)

NST204 - Nanotechnology in Medical Science

[L-T-P = 3-1-0] Credit: 4

Module - I [8L]

Principles of drug delivery systems, Nanodrugs for diagnosis and treatment of cancer; concept of nanodrug encapsulation, self-assembly, controlled release (targeted and triggered release),

nanoparticle recovery; Nanoparticles for Photodynamic Therapy of cancer; nanoparticle assisted vaccine development; nanoshells for surgery.

Module - II [8L]

DNA nanotechnology, Protein & glyco nanotechnology, Lipid nanotechnology, Bio-nanomachines, Carbon nanotube and its bio-applications

Module - III [8L]

Nanotechnology in tissue engineering, Nano artificial cells, Nanotechnology in organ printing

Module - IV [8L]

Nanodiagnostics, Nanoarrays for diagnostics, detection of single DNA, self-assembled protein nanoarrays, protein nanobiochip, nanoparticles for molecular diagnostics, DNA nanomachines, Quantum dot conjugation strategies with DNA-aptamer, Protein and Antibody and FRET/BRET based assays for Cancer, AIDS, tuberculosis and other disease diagnostics

Module - V [8L]

Biosensor and nanobiosensor: Biosensor and nanobiosensor basic concepts, characterization, perception, Nanobiosensor, CNT biosensor, DNA nanosensor, Nanowire biosensor, Enzyme–metal NP hybrids for biosensing and for the generation of nanostructures, Biomolecule– semiconductor NPs for biosensing,. Nanoprobes for analytical applications

Reference books:

1. Biomedical Nanotechnology, by N.H Malsch. CRC Press. (2005).
2. The Handbook of Nanomedicine, by K.K. Jain. Humana press. (2008).
3. Nanotherapeutics: Drug Delivery Concepts in Nanoscience, by A. Lamprecht. Pan Stanford Publishing Pte. Ltd. (2009).
4. Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact, by C. S. S. R. Kumar, J. Hormes and C. Leuschner. WILEY -VCH Verlag GmbH & Co. (2005).
5. Essentials of nanotechnology by Jeremy Ramsden
6. Nanotechnology in Biology and Medicine: Methods, Devices and Application by Tuan Vo-Dinh .CRC press, 2007.

NSP211 - Nanotechnology Lab-II

[L-T-P = 0-0-9] Credit: 3

1. Removal of pollutants and heavy metals from water
2. Observing Rabi splitting through absorption study of interaction between different metal nanoparticles and several cyanine dye J-aggregates.

3. Photocatalytic activity of nanomaterials.
4. Thin film preparation by spin coating technique
5. Biogenic synthesis of silver/gold nanoparticles
6. Synthesis of carbon nanotubes/ nanofibers.

NSP212 - Biology Lab-II

[L-T-P = 0-0-6] **Credit: 2**

1. Introduction to Microbial culture/animal cell culture/plant tissue culture
2. Analysis of protein by SDS-PAGE
3. Western blotting and ELISA
4. Cellular uptake study of nanoparticles by confocal microscopy
5. Cell cycle analysis of nanoparticle-treated cells by flow cytometry

NSP213 - Computational Nanoscience Lab-II

[L-T-P = 0-0-6] **Credit: 2**

1. Introduction to Linux and common terminal commands
2. Python programming and packages
3. Information visualization using R, Python, Tableau/Power BI
4. Numerical simulation of optical properties (absorption cross-section, scattering cross-section, electric field distribution etc.) of nanoparticles