UNIVERSITY OF MUMBAI
No. UG/336 of 2018

CIRCULAR:-

Attention of the Head, University Department of Nano Science and Nano Technology and the Principals of the affiliated Colleges in Science and the recognized Science Institutions is invited to this office Circular No. UG/259 of 2006 dated 17th July, 2006 relating to syllabus of the M.Sc. in Nano-Sciences and Nano-Technology (Sem. I & II). They are hereby informed that the recommendations made by Board of Studies in Nano-Sciences and Nano-Technology at its meeting held on 29th November, 2017 have been accepted by the Academic Council at its meeting held on 11th December 2017 **vide** item No.4.4 and that in accordance therewith, the revised syllabus of M.Sc. in Nano-Sciences and Nano-Technology (Sem. I & II), has been brought into force with effect from the academic year 2017-18, accordingly. The same is available on the University's website: www.mu.ac.in.

MUMBAI – 400 032
8th February, 2018

(Dr. Dinesh Kamble)
I/c REGISTRAR

To

The Head University Department of Nano-Sciences and Nano-Technology and the Principals of the affiliated Colleges in Science and the recognized Science Institutions.

A.C/4.4/11/12/2017

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No. UG/336-A of 2018 MUMBAI-400 032 8th February, 2018

Copy forwarded with Compliments for information to:-

1) The Co-ordinator, Faculty of Science & Technology,
2) The Director, Board of Examinations and Evaluation,
3) The Director, Board of Students Development,
4) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

AC 11th December, 2017

Item No. 4.4

UNIVERSITY OF MUMBAI

Revise Syllabus for the M.Sc.
Semester I and Semester II
Program: M.Sc. Course
Nano Science and Nano Technology

(Choice Based Credit System with effect from the academic year 2017–2018)

Date: 29/11/2017

To,

Dr. Vijay Joshi
The Dean,
Faculty of Science,
University of Mumbai,
Mumbai-400032.

Sub.: Syllabus of M.Sc. in Nanosciences and Nanotechnology to be placed in Academic council for its approval

Sir,

The meeting of Board of studies in Nanosciences and Nanotechnology was held on 29th Nov.2017, at 10.30am at NCNNUM, University of Mumbai, to discuss and approve the revision of syllabus for M.Sc. in Nanosciences and Nanotechnology for first and second semester. Attached herewith is the minutes of meeting and copy of syllabus. The committee has finalized the revised syllabus and recommended to place as an item in the 'Academic Council" for its approval.

Thanking you.

Yours Sincerely,

Bellare 29/11/2017

Dr. JAYESH BELLARE, Ph.D.
Professor, Chemical Engineering
I. I. T. Bombay, Powai
Mumbai - 400 076. INDIA

Prof. Jayesh Bellare

(Chairman, BOS)

Encl.

1. Copy of Minutes of meeting BOS Nanosciences and Nanotechnology.
2. Syllabus of M.Sc. Nanosciences and Nanotechnology

Minutes of Meeting: Board of Studies - Nanoscience and Nanotechnology

Agenda: To discuss and approve the revision of syllabus for M.Sc in Nanosciences and Nanotechnology.

The meeting of BOS (Nanoscience and Nanotechnology) was held on 29th Nov 2017, 10.30am at NCNNUM, University of Mumbai, to discuss and approve the revision of syllabus for M.Sc in Nanosciences and Nanotechnology.

Following committee members were present:

- Prof. Jayesh Bellare (Chairman)
- Prof. P.M. Dongre (Member)
- Prof. A.K. Srivastava (Member)
- Prof. Santosh Haram (Member and Director, NCNNUM)
- Prof. Sandesh Jaybhaye (Member) was consulted through teleconferencing during the meeting.

Committee discussed the report of the syllabus committee appointed to revise the syllabus of M.Sc. in Nanosciences and Nanotechnology. After the discussions, the members suggested some minor changes which were incorporated and approved.

The committee has recommended this revised syllabus for M.Sc. in Nanosciences and Nanotechnology to place as an item in the 'Acadamic Council' for its approval.

29/11/2017

Prof. Jayesh Bellare
(Chairman, BOS)

Prof. P.M. Dongre
(Member)

29/11/2017

Prof. A.K. Srivastava
(Member)

Prof. Santosh Haram
(Member and Director, NCNNUM)

Minutes of the meeting

Meeting schedule : BOS for M.Sc. course work in Nanosciences and Nanotechnology
Meeting Venue : National Centre for Nanosciences and Nanotechnology, University of Mumbai
Date of the Meeting : 9th Aug. 2017

Members:

1. Prof. Jayesh Bellare, Chairman BOS, IIT Bombay
2. Prof. A.K. Srivastava, Department of Chemistry, University of Mumbai
3. Prof. Prabhakar Dongre, Department of Bio-Physics, University of Mumbai
4. Prof. Radha Jayram, Department of Chemistry, ICT, Mumbai
5. Prof. Santosh Haram, Director NCNNUM University of Mumbai

Following faculty members of NCNNUM were presented as observers.

1 Dr. Atul Chaskar, NCNNUM, University of Mumbai
2 Dr. Suhas Jejurikar, NCNNUM, University of Mumbai
3. Dr. Pravin Walke, NCNNUM, University of Mumbai
4. Dr. Bhavesh Sinha, NCNNUM, University of Mumbai
5. Dr. Kunjal Shah, NCNNUM, University of Mumbai

Minutes:

Prof Santosh Haram welcome all the members and brief them about center and various courses NCNNUM is aspired to start. The chairman informed the committee that the M.Sc. Course in Nanosciences and nanotechnology will be of 4 semesters (Total Credit: 96; (each semester will carry 24 credits with choice based credit system)). Prof. Srivastava informed to the member that each paper will have four credits as per the new UGC rules and regulations which Mumbai University has adopted. After the fruitful discussion, it has been decided to finalized first two semesters of the course. It has been proposed to have full semester project work at forth semester to facilitate substantial publishable research work from the students. It will also help to carry out internship in the industry.

Following course structure for the first two semesters have been proposed.

Semester I : number of theory papers : 04; number of practical or lab courses : 04
Semester II : number of theory papers : 04; number of practical or lab courses : 04

The details are as bellow

Semester I (Total credits : 24)

Paper Code	Subjects	Credits
CNN-101	Essential Physics	4
CNN-102	Essential Chemistry	4
CNN-103	Essential Mathematics	4
CNN-104	Essential Biology	4
CNN-111	Phys. Lab I	2
CNN-112	Phys. Lab II	2
CNN-113	Chem. Lab I	2
CNN-114	Chem. Lab II	2
	Total	24

Proposed Syllabus:

Essential Physics (CNN-101)

Mathematical Methods (10 L)

Vector and tensor analysis, Ordinary differential equations, Matrix algebra, Systems of linear equations.

The elementary principles (6 L)

Mechanics of a particle, Mechanics of a system of particles, Constraints, Motion of charged particles, Velocity dependent potentials,

Atoms and Molecules (Part-I) (14 L)

Particle like properties of radiation (photoelectric Effect, Compton Effect, Dual Nature of Electromagnetic Radiation, photons), Wavelike properties of particle (Matter Waves, The Wave-Particle Duality, Properties of Matter Waves), Various models of atom (Thomson's Model, Rutherford's Model, Stability of the Nuclear Atom, Atomic Spectra, Bohr's Postulates, Bohr's Model, Correction for Finite Nuclear Mass, Atomic Energy States, Interpretation of the Quantization Rules, Sommerfeld's Model, The Correspondence Principle)

Electronics (10 L)

Basic working principles of A.C. and D.C. circuits, Transistors, Power Amplifiers, Digital Electronics-Logic gates, Arithmetic circuits, Flip Flops, Digital integrated circuits NAND & NOR gates as building blocks, X-OR Gate, simple combinational circuits

Reference Books

- Methods of Mathematical Physics Vol.-I by Dr. R. Courant and D. Hilbert, Interscience Publishers, Inc., New York
- Mathematical Methods for Physicists by Tai Chow, Cambridge University Press.
- Mathematical Physics A Modern Introduction to its Foundation by S. Haasani, Springer
- Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles by R. Eisberg, John Wiley and Sons
- Fundamentals of Molecular Spectroscopy by W. S. Struve, John Wiley and Sons
- Fundamentals of Molecular Spectroscopy by C. N. Banwell, McGraw-Hill
- Electronic Principles by A. Malvino and D. Bates,

Essential of Chemistry (CNN-102)

1. Chemical Kinetics and Reaction Dynamics (15L)

Accounting for the rate laws: simple reactions, temperature dependence of reaction rates, consecutive reactions, (rate determining step approximation and steady-state approximation), pre-equilibria, unimolecular reactions – Lindemann-Hinshelwood mechanism.

Kinetics of complex reactions - Chain reactions, polymerization reactions, explosions, photochemical reactions.

Fast reactions: Study of kinetics by stop-flow technique, relaxation methods, flash photolysis, magnetic resonance method.

Molecular reaction dynamics – collision theory, steric factor, diffusion controlled reactions, activated complex theory, reaction coordinate and transition state, thermodynamic aspects, reaction between ions, salt effects, dynamics of molecular collisions, potential energy surfaces.

Homogeneous catalysis – enzyme catalysis, Michael-Menten mechanism, acid base catalysis, autocatalysis, oscillating reactions.

Heterogeneous catalysis – catalytic activity at surfaces. Examples: hydrogenation, oxidation, cracking and forming.

References:

- Chemical kinetics and reaction dynamics by Paul A Houstons
- Physical Chemistry by Donald A. McQuarrie and John D. Simon.

2. Chemical Thermodynamics (15)

State functions and exact differentials. Internal Energy, Enthalpy, Heat Capacity, Joule-Thomson coefficient. Clausius inequality, Entropy, Maximum Work, Thermodynamic equation of state, Maxwell relations, Helmholtz and Gibbs free energy, Temperature dependence of thermodynamic functions.

Partial molar quantities, Chemical potential, Chemical potentials for ideal gases , gas mixtures and homogeneous solutions in multi component systems. Free energy, entropy and enthalpy of mixing for ideal gas mixtures and solutions, Fugacity and its relation to pressure, Equilibrium constant and its dependence on temperature and pressure.

Vapor pressure – composition diagrams, Activity and activity coefficients, Excess functions, Gibbs-Duhem equation.

Third law of thermodynamics, temperature dependence of entropy

Phase rule and Phase Equilibria. Phase diagrams and their classification. Lambda transitions. Phase diagrams for partially miscible liquids for two components. Three Component Systems (Graphical representations of systems of three liquids, one pair of partially miscible liquid, bimodal curves, plait point, influence of temperature.)

Experimental techniques for determination of thermodynamic quantities.

Applications of Thermodynamics to Fractional Distillation, Zone Refining, Fuel Cells and Corrosion Processes.

Thermodynamics of surfaces, Gibbs adsorption isotherm.

Debye-Hückel theory, ionic atmosphere, activity coefficients of electrolyte solutions: Debye-Hückel limiting law, extension to higher concentrations.

Electrolytic conductance and ion-ion interactions, Debye-Hückel-Onsager equation*, Debye-Falkenhagen effect, Wien effect.

References:

- Peter Atkins and Julio de Paula, *Atkin's Physical Chemistry*, 7th ed., Oxford University Press, 2002.
- K. J. Laidler and J. H. Meiser, *Physical Chemistry*, 2nd ed., CBS Publishers and Distributors, New Delhi, 1999.
- Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd ed., John Wiley and Sons (Asia) Pte. Ltd., 2002.
- Ira R. Levine, *Physical Chemistry*, 5th ed., Tata McGraw-Hill, New Delhi, 2002.
- G. W. Castellan, *Physical Chemistry*, 3rd ed., Narosa Publishing House, New Delhi, 1983.
- S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
- W. G. Davis, *Introduction to Chemical Thermodynamics – A Non-Calculus Approach*, Saunders, Philadelphia, 1972.
- I. M. Klotz and R. M. Rosenberg, *Chemical Thermodynamics*, 5th ed., John Wiley and Sons, Inc., 1994.
- Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.

2. **Chemical Bonding and Organometallic Chemistry (15)**

Hybridisation: Derivation of wave functions for the following orbital hybridisation types: sp (BeH_2); sp^2 (BF_3); sp^3 (CH_4) considering only sigma bonding.

Molecular Orbital Theory (LCAO-MO approach) for (a) Electron deficient species (B_2H_6), and (b) Electron rich species (tri-iodide ion, I_3^-).

Hydrogen bonding – concept, types, properties, methods of detection and importance. Van der Waal's forces, ion-dipole, dipole-dipole, London forces.

Bent's Rule. Reactivity of molecules: e.g. chlorofluorides of phosphorous, fluoromethanes, etc.

Synthesis, structure and bonding in the following organometallic compounds:

(a) Alkyl and Aryl derivatives, (b) Carbenes and Carbynes, (c) Alkene complexes, (d) Alkyne complexes, (e) Allyl complexes, (f) Cyclopentadiene complexes and (g) Arene complexes (sandwich and half sandwich complexes).

Sixteen electron rule and electron counting with examples.

References:

- R. C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2nd ed., New Age International Pvt. Ltd., 2000.

- Gary O. Spessard and Gary L.Miessler, Organometallic Chemistry, Prentice-Hall, 1977.
- R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5th ed., Wiley Interscience, 2009.
- K. F. Purcell and J. C. Klotz, Inorganic Chemistry, Saunders, Hongkong, 1977.
- B. Douglas, D. H. McDaniel and J. J. Alexander. Concepts and Models of Inorganic Chemistry, 2nd Ed., John Wiley & Sons, 1983.
- Durrant and Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.
- R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin / Cummings Publishing Company, 1989.
- James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993.
- Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004.
- R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., Calcutta, 2001.
- C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
- J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, New York, 1978.
- George A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., New York, 1997.
- Shriver & Atkins' Inorganic Chemistry 5th Edition
- Coulson's Valence Oxford University Press

3. Surface Chemistry and Colloids (15L)

The colloidal state: Introduction; Classification and colloidal systems; Structural characteristics; Preparation and purification of colloidal systems:

Kinetic properties: The motion of particles in liquid media; Brownian motion and translational diffusion; The ultracentrifuge; Osmotic pressure; Rotary Brownian motion:

Optical properties: Optical and electron microscopy; Light scattering:

Liquid-gas and liquid-liquid interfaces; Surface and interfacial tensions; Adsorption and orientation at interfaces; Association colloids-micelle formation; spreading; Monomolecular films:

The solid-gas interface: Adsorption of gases and vapours on solids; Composition and structure of solid surfaces:

The solid-liquid interface; Contact angles and wetting; Ore flotation; Detergency; Adsorption from solution:

Charged interfaces: The electric double layer; Electrokinetic phenomena; Electrokinetic theory:

Colloid stability: Lyophobic sols; Systems containing lyophilic material; Stability control:

Rheology: Introduction; Viscosity; Non-Newtonian flow; Viscoelasticity: 10. Emulsions and foams: Oil-in-water and water-in-oil emulsions; Foams

References:

- A.W. Admson, Physical Chemistry of Surfaces (5th Ed.), Wiley-Interscience (1990)
- AVEYARD, R. and HAYDON, D.A., An Introduction to the Principles of Surface Chemistry, Cambridge University Press (1973)
- HIEMENZ, P.C., Principles of Colloid and Surface Chemistry (2nd Ed.), Dekker (1986)

- MATIJEVIC, E. (editor), Surface and Colloid Science, Vols 1- , Wiley Interscience (1969
- ROSEN, M.J., Surfactants and Interfacial Phenomena, Wiley (1978)
- ROSS, S. and MORRISON, I.D., Colloidal Systems and Interfaces, Wiley (1988)
- TADROS, Th.F. (editor), Surfactants, Academic Press (1984)

Essential Mathematics (CNN-103)

1. Analysis and linear Algebra (10 L)

One-variable calculus: Real and Complex numbers; Convergence of sequences and series; Continuity, intermediate value theorem, existence of maxima and minima; Differentiation, mean value theorem, Taylor series; Integration, fundamental theorem of Calculus, improper integrals. Linear Algebra: Vector spaces (over real and complex numbers), basis and dimension; Linear transformations and matrices. Vector spaces: Basis and dimension, Direct sums. Determinants: Theory of determinants, Cramer's rule. Linear transformations: Rank-nullity theorem, Algebra of linear transformations, Dual spaces. Linear operators, Eigenvalues and eigenvectors, Characteristic polynomial, Cayley- Hamilton theorem, Minimal polynomial, Algebraic and geometric multiplicities, Diagonalization, Jordan canonical Form.

2. Trigonometry (5 L)

Introduction to trigonometry (theorem of Pythagoras, trigonometric ratios and acute angles, functional forms); Trigonometric waveforms (graphs of trigonometric wave functions, the propagation of wave, sinusoidal forms, waveform harmonics);

3. Functional Analysis (7 L)

Basic topological concepts, metric spaces, normed linear spaces, Banach spaces, bounded linear functionals and dual spaces, the Hahn-Banach Theorem, bounded linear operators, open-mapping theorem, closed-graph theorem, the Banach-Steinhaus Theorem, Hilbert spaces, the Riesz Representation Theorem, orthonormal sets, orthogonal complements, bounded operators on a Hilbert space up to the spectral theorem for compact, self-adjoint operators.

4. Complex Analysis (8 L)

Harmonic and subharmonic functions, Green's function, and the Dirichlet problem for the Laplacian; the Riemann mapping theorem (revisited) and characterizing simple connectedness
in the plane; Picard's theorem; the inhomogeneous Cauchy–Riemann equations and applications; covering spaces and the monodromy theorem.

Essential Biology (CNN-104)

Molecules of Life (15 L)

Water (Structure, properties and physiological importance; pH and biological buffer systems); Carbohydrates (Classification, structures, properties and functions); Lipids (Classification, nomenclature, structure of fatty acids, Chemical properties and functions of phospholipids, biological significance of lipids) ; Amino acids (Classification based on polarity, nutritional and metabolic requirement, structure and properties); Proteins (Function and properties, peptide bond, protein structure-primary, secondary, tertiary and quaternary); forces stabilizing the structure of proteins and other macromolecules Enzymes (Classes and functions, mechanism of action of enzymes, regulation of enzymes); Nucleic acids (Structure of purines, pyrimidines, nucleoside, nucleotide, DNA and RNA, Types and properties of Nucleic acids, Central dogma of molecular biology).

Biophysical Techniques (15 L)

Observation of cells – Microscopy; Isolation and breaking of cells; Preparation of biological samples for analysis; Separation of cells – Centrifugation; Isolation, purification and characterization of Biomolecules; Separation and purification techniques - Chromatography and Electrophoresis; Spectrophotometry; Isotope trace technique and autoradiography; Tools to study the conformation of macromolecules and their interactions

Cell Biology (15 L)

Chemical nature of cells; Structure of Cells (Prokaryotic – Bacteria and Archaebacteria, Eukaryotic- fungal, plant and animal Viruses – Structure and classification); Ultra structure of Cell membrane and Cell wall: Chemical Composition; Models and their functions Ultra structure of Cytoplasm and Cytoplasmic organelles (Golgi bodies, Endoplasmic reticulum, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Nucleus, Cytoskeleton, Cilia, Flagella and Chloroplast); Transport of substances through the cell membrane: Osmosis, Diffusion; Types of Transport - Active transport (Sodium-Potassium pump) and Passive transport; Membrane potential: measuring membrane potential, action potential.

Cell Signaling, Immune system and Bio-sensors (15 L)

Cell communication - Signaling molecules & their receptors; Functions and types of cell surface receptors; Signal transduction pathways; Signal transduction and cytoskeleton; Regulation of programmed cell death; Immunity- innate and adaptive immunity; Introduction to antigen presenting cells complement system and tumor immunology; Life cycle of HIV; Monoclonal antibodies synthesis and applications. Nature in the construction of Nano-scale biosensor devices and motors: ATP synthesis as a nanomotor; Use of DNA and proteins as actuators, chips, sensors and electronic circuits.

Reference Books

T M Apostol, Calculus, Volume I, 2nd. Edition, Wiley, India, 2007.
G. Strang, Linear Algebra And Its Applications, 4th Edition, Brooks/Cole, 2006.
Artin, M., Algebra, Prentice-Hall of India, 1994.
Herstein, I. N., Topics in Algebra, Vikas Publications, 1972.
Strang, G., Linear Algebra and its Applications, Third Edition, Saunders, 1988.
Halmos, P., Finite dimensional vector spaces, Springer-Verlag (UTM), 1987.
Narasimhan, R., Complex Analysis in One Variable, 1st ed. or 2nd ed. (with Y.Nievergelt), Birkhauser (2nd ed. is available in Indian reprint, 2004).
Greene, R.E. and Krantz, S.G., Function Theory of One Complex Variable, 2nd ed., AMS 2002 (available in Indian reprint, 2009, 2011).

Phys. Lab I (CNN-111)

1. Two probe- Four probe conductivity measurement techniques.
2. Hall effect, mobility and carrier concentration measurements for semiconductor.
3. Parallel Plate Capacitor & Dielectric Constant Experiment
4. Determine Young's modulus of elasticity of metal wire by using Searle's apparatus
5. Determine Joule's constant (J) by electrical method (specific heat of a liquid).
6. Susceptibility measurement using Guoy Method
7. Study of Photoelectric effect, inverse square law and LDR

Phys. Lab II (CNN-112)

1. Verify law of resistances in series by using Meter Bridge
2. Determine specific resistance by voltmeter ammeter method
3. Velocity of sound by resonance tube
4. Calculate coefficient of linear expansion of a metal rod using Pullinger's apparatus.
5. Thin film deposition and thickness measurements
6. XRD analysis of powder sample, single crystals and nano materials
7. Raman spectroscopy for carbon allotropes
8. FTIR analysis for organic materials
9. Ultra Violet spectroscopy to extract band gap measurements
10. Transistor and diode characteristics

Chemistry Lab I (CNN-113).

- Titration of a mixture of trichloroacetic acid, monochloroacetic acid and acetic acid with sodium hydroxide conductometrically.
- Verification of Ostwald's dilution law and determination of the dissociation constant of a weak monobasic acid conductometrically.
- Study of the effect of substituent on dissociation constant of acetic acid conductometrically.
- Determination of concentrations and amounts of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.
- Devarda's Alloy: Cu by EDTA method, Al by Gravimetry using oxine.
- Cu-Ni Alloy: Cu by iodometric method; Ni gravimetrically by DMG method.

Chem. Lab II (CNN-114)

- Determine of the formula of the silver-ammonia complex by potentiometric method.
- Determination of pK values of phosphoric acid by potentiometric titration with sodium hydroxide using a glass electrode.
- Determination of acidic and basic dissociation constants of an amino acid and hence the isoelectric point of the acid.

- Determination of the stability constant of the complex formed between iron(III) and 5-sulphosalicylic acid at pH =2 and pH=3 by colourimetric method.
- Determination of solubility product of silver chloride potentiometrically using a concentration cell.
- Solder Alloy: Sn gravimetrically by oxide method; Pb by EDTA method.
- Lime Stone Ore: Loss on ignition; Ca by EDTA method.
- Haematite Ore: Acid insoluble residue; Fe by redox titration.

Semester II (Total credits : 24)

Course structure:

Code	Subjects	Credits
CNN-201	Solid State Physics	4
CNN-202	Fundamentals of nano materials	4
CNN-203	Interaction of matter with radiations	4
CNN-204	Experimental Methods	4
CNN-211	Synthesis and Characterization of nanomaterials (Practical)	2
CNN-212	Synthesis and Characterization of Biomolecules and Biomaterials (Practical)	2
CNN-213	Vacuum systems and techniques (Practical)	2
CNN-214	Laboratory IV (Practical)	2
	Total	24

- **Solid State Physics (CNN-201) (30 L)**

  Crystal Structure (Periodic Array of Atoms, Fundamental Types of Lattices, Index System for Crystal Planes, Simple Crystal Structures, Direct Imaging of Atomic Structure, Non-ideal Crystal Structures, Crystal Structure Data.),Wave diffraction and the reciprocal lattice (Diffraction of Waves by Crystals, Scattered Wave Amplitude, Brillouin Zones, Fourier Analysis of the Basis), Crystal Binding and Elastic Constants (Crystals of Inert Gases, Ionic Crystals, Covalent Crystals, Metals, Hydrogen Bonds, Atomic Radii, Analysis of Elastic Strains, Elastic Compliance and Stiffness Constants, Elastic Waves in Cubic Crystals), Phonons (Vibrations of Crystals with Monatomic Basis, Two Atoms per Primitive Basis, Quantization of Elastic Waves, Phonon Momentum, Inelastic Scattering by Phonons, Phonon Heat Capacity, Anharmonic Crystal Interactions, Thermal Conductivity), Solids-conductors and semiconductors (Types of Solids, Band Theory of Solids, Electrical Conduction in Metals, The Quantum Free-Electron Model, The Motion of Electrons in a Periodic Lattice, Effective Mass, Electron-Positron Annihilation in Solids, Semiconductors, Semiconductor Devices, Superconductivity, Magnetic Properties of Solids, Paramagnetism, Ferromagnetism, Antiferromagnetism and Ferrimagnetism), Plasmons-Polaritons and Polarons (Dielectric Function of the Electron Gas, Plasmons, Electrostatic Screening, Polaritons, Electron-Electron Interaction, Electron-Phonon Interaction: Polarons, Peierls Instability of Linear Metals), Nanostructures (Electronic Structure of 1D Systems, Electrical Transport in 1D, Electronic Structure of 0D Systems

Reference Books:

- Introduction to Solid State Physics by C. Kittel,
- Elementary Solid State Physics by Ali Omer,
- Solid-State Physics by N. Ashcroft and D. Mermin

Fundamentals of nano materials (CNN-202)

Introduction to miniaturization (1 L)

Background, Scaling Laws (scaling in mechanics, scaling in electricity and electromagnetism, scaling in optics, scaling in heat transfer, scaling in fluids) and accuracy of scaling laws

Nanomaterials (4 L)

Background, bonding atoms to make molecules and solids (ionic bonding, covalent bonding, metallic bonding), Various forces (The dispersive force, repulsive force, van der Waals force), Structures (particles, wires, films, layers, coatings, porous materials, small grained materials), molecules (carbon fullerenes and nanotubes, dendrimers, etc)

Synthesis of Nanomaterials (10 L)

Physical Methods (Mechanical, evaporation, chemical vapour deposition, Electric arc, Ion beam techniques, molecular beam epitaxy); *Chemical Methods* (colloids and colloids in solution, Langmuir-Blodgett (L-B) method, micro emulsion, Sol gel method, etc.); *Biological Methods* (using microorganisms, using plant extracts, using proteins and template like DNA, etc.)

Some Special Nanomaterials (5 L)

Background, carbon nanotubes, porous silicon, aerogels, zeolites, self-assembled nanomaterials, core shell particles, etc.

Properties of Nanomaterials (5 L)

Mechanical, structural, electrical, optical and magnetic

Applications (5 L).

Energy, electronics, automobiles, sports, textiles, cosmetics, domestic applications, biotechnology and medical field, space and defense, environment

Reference Books:

1. Nanotechnology: principles and practices by S. K. Kulkarni, Capital publishing company
2. Nanotechnology the whole story by B. Rogers, J Adams and S. Pennathur, CRC Press

Interaction of matter with radiations (CNN-203)

- **Quantum Mechanics (15 L)**

  The physical basis of quantum mechanics (experimental background, old quantum theory, the Heisenberg Uncertainty Principle, wave packets in space and time), the Schrödinger wave equation (development of the wave equation, interpretation of the wave function, energy eigenfunction, 1-D square wave potential), operators of Quantum Mechanics (state vectors, observables and operators, ket-space, bra-space and inner product, Hermitian), Representations in different bases Time-evolution of a quantum system (Schrödinger, Heisenberg and Interaction pictures), 1-D problems in quantum mechanics (wells and barriers, Harmonic oscillator, etc.),

- **Atoms and Molecules (Part-II) (15 L)**

  Multielectron atoms (identical Particles, The Exclusion Principle, Exchange Forces and the Helium Atom, Ground States of Multielectron Atoms and the Periodic Table, X-Ray Line Spectra, Alkali Atoms, Atoms with Several Optically Active Electrons, LS Coupling, energy

Levels of the Carbon Atom, The Zeeman Effect), Molecules (Ionic Bonds, Covalent Bonds, Molecular Spectra, Rotational Spectra, Vibration-Rotation Spectra , Electronic Spectra

Reference Books:

- Introduction to quantum mechanics by D. Griffiths, Prentice Hall
- Principles of Quantum Mechanics by R. Shanka, Plenum Press
- Quantum Mechanics by L. I. Schiff, McGrew Hill
- Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles by R. Eisberg, John Wiley and Sons
- Fundamentals of Molecular Spectroscopy by W. S. Struve, John Wiley and Sons
- Fundamentals of Molecular Spectroscopy by C. N. Banwell, McGraw-Hill

Experimental Methods (CNN-204) (30 L)

Vacuum and Ultra-High Vacuum systems, : Fundamentals of vacuum, free gas, volume and surface gas, flow of gas, pumping techniques, vacuum measurements (pressure and spectral measurements), vacuum equipment, applications of vacuum techniques. Ion and thin film techniques: Thermal evaporation (electron gun, laser ablation, reactive deposition). Ion techniques, plasma fundamentals, sputtering, magnetron discharge, ion guns, implantation, etching. Chemical and electro-chemical methods, CVD (chemical vapor deposition), Methods of surface and structure analysis, X-rays, STM, TEM, SIMS, RBS, XES, Low temperature measurement techniques,

Reference Books:

- Handbook of Vacuum Science and Technology by D. M. Hoffman, B. Singh and J. H. Thomas, Academic Press

Synthesis and Characterization of nanomaterials Lab Course (CNN-211)

- Synthesis of metal nanoparticles by wet chemical method
- Synthesis of semiconductor quantum dot by reverse surfactant method
- Synthesis of bimetallic nanoparticles by wet method
- Synthesis of metal oxide nanoparticle by sol-gel method
- Synthesis of metal nanoparticles by solvothermal method

Synthesis and Characterization of Biomolecules and Biomaterials: Lab Course (CNN-212)

- Synthesis & charactenzation of metal nanoparticles using biological methods
- Study Antibacterial activity using Nanoparticles
- Analysis of biological samples by environmental SEM/TEM/XRD/Spectrophotometry
- Study of biocompatibility of nanoparticles.
- Functionalization of nanoparticles

Vacuum systems and techniques Lab Course(CNN-213)

- Hands on experience with vacuum pumps
- Hands on experience with vacuum gauges

- Hands on experience with thermal evaporation setup
- Demonstration of DC sputtering setup
- Demonstration of Pulsed Laser Deposition setup
- Hands on experience with organic film growth using Glove Box
- Film Thickness measurement using optical profilo meter
- Low Temperature Resistivity Measurement of a thin film

Laboratory IV (CNN-214)

- Raman and FTIR Spectroscopy analysis of Nanophase materials
- Time resolved spectroscopy of quantum dots
- Cyclic voltammetry of semiconductor quantum dots
- HER, OER and ORR reaction analysis by rotating disc electrode.
- Electrochemical impedance spectroscopy analysis of heterojunctions.

3. For any additional courses where in-house faculties are not available, committee suggested to get commitment from the outside faculties in advance.

4. Committee suggested to get the internal approval of academic courses from the committee members after detailing of courses.

Prof. Jayesh Bellare
(BOS Chairman)

Prof. A.K. Srivastava
(syllabus Committee member)

Prof. P. M. Dongre
(BOS and syllabus Committee member)

Prof. Radha Jayram
(syllabus Committee member)

Prof. Santosh Haram
(BOS member and convener, syllabus committee)