M.Tech Programme in Nanoscience (NS) & Nanoelectronics (NE)

Sl. No.	Name of Centre	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination	Pattern of Examination
1	Special Centre for Nano Sciences	Nanoscience – NNST (182)	**Syllabus for JNU entrance exam to M. Tech in Nano-Science/Nano-Electronics** **Part A: Research Methodology:** Numerical Ability: Numerical computation, numerical estimation, numerical reasoning and data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting. Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; Elementary physics, chemistry, biology, mathematics. Opto-electronic devices (solar cells, photo-detectors, LEDs). A/D and D/A converters. Microscopy techniques. Resolving powers of different microscopes. Spectroscopy techniques. UV/visible, fluorescence, NMR spectroscopy, different types of mass spectrometry and surface plasma resonance methods **Part B-1: Subject specific** **NNSP(182) Nanoscience** **Chemical sciences :** **Inorganic Chemistry** Chemical periodicity, Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory). Concepts of acids and bases, Hard-Soft acid base concept. Main group elements and their compounds: Allotropy, synthesis, structure and bonding. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties. Inner transition elements: spectral and magnetic properties. Organometallic compounds: synthesis, bonding and structure, and reactivity. Nuclear chemistry: nuclear reactions, fission and fusion. **Physical Chemistry** Basic principles of quantum mechanics: Postulates; operator algebra; exactly- solvable systems: particle-in-a-box and the hydrogen atom.Chemical bonding in diatomics; elementary concepts of MO and VB theories. Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Le Chatelier principle. Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems. Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications. Chemical kinetics: Empirical rate laws, order of reaction, zero order, first order, second order and pseudo order reactions, temperature dependence. Solid state: Crystal structures; Bragg's law and applications; band structure of solids. Polymer chemistry: Different classification of polymers, Molar masses and their calculations. **Organic Chemistry** IUPAC nomenclature of organic molecules. Principles of stereochemistry: isomerism in acyclic and cyclic compounds. Aromaticity: Benzenoid and non-benzenoid compounds – (4n+2) Rule. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways. Common named reactions and rearrangements – applications in organic synthesis. **Physical sciences:** Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Scalar and Vector potentials, Maxwell equations. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. The first and second laws of thermodynamics, Thermodynamic functions, heat capacity, enthalpy, entropy. Bravais lattices. Miller indices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Diamagnetism, Paramagnetism, Ferromagnetism, Ferrimagnetism, Anti-ferromagnetism. Dielectric Materials; Types of Polarization; Piezoelectricity, Pyroelectricity and Ferroelectricity **Biosciences**	Paper will be OBJECTIVE type
2		Nanoelectonics – NNET (190)		

Unit-I: Biomolecules and their interactions: Composition, structure, function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.). Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers. Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation and isozymes. Conformation and stability of nucleic acids and proteins. Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

Unit-II:Cell Biology and cell communication: Membrane structure and function; Structural organization and function of intracellular organelles; Cell division and cell cycle. Microbial physiology. Cell signalling (hormones and their receptors, cell surface receptor, signal transduction pathways, bacteria and plant component systems)

Unit-III: Fundamental Processes: DNA replication, repair and recombination, RNA synthesis and processing and Protein synthesis

Unit-IV :Immunology: Cells and molecules involved in innate and adaptive immunity, antigens, antigenicity and immunogenicity. B and T cell epitopes, structure and function of antibody molecules. Monoclonal antibodies, antigen-antibody interactions, humoral and cell-mediated immune responses, the complement system, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, congenital and acquired immune deficiencies, vaccines.

Unit V: Genetics: Mendelian principles, concept of gene: Allele, multiple alleles, pseudoallele, complementation tests, mutation types and cause.

Unit-VI : Plant Physiology: Photosynthesis (Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C3, C4 and CAM pathways). Solute transport and photoassimilate translocation.

Unit VII: Human Physiology: Blood corpuscles, blood coagulation, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.

Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.

Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation and neuroendocrine regulation.

Type of paper: Paper will be **OBJECTIVE**.

Part B-2 (Engineering Sciences)

NNEP(190) Nanoelectronics

Unit-I

Electronic Transport in semiconductor, PN Junction, Diode equation and diode equivalent circuit. Breakdown in diodes, Zener diodes, Tunnel diode, Semiconductor diodes, characteristics and equivalent circuits of BJT, JFET, MOSFET, IC fabrication-crystal growth, epitaxy, oxidation, lithography, doping, etching, isolation methods, metalization, bonding, Thin film active and passive devices. Rectifiers, Voltage regulated ICs and regulated power supply, Biasing of Bipolar junction transistors and JFET. Single stage amplifiers, Multistage amplifiers, Feedback in amplifiers, oscillators, function generators, multivibrators, Operational Amplifiers (OP AMP) -characteristics and Applications, Computational Applications, Integrator, Differentiator,

Unit-II

Superposition, Thevenin, Norton and Maximum Power Transfer Theorems, Network elements, Network graphs, Nodal and Mesh analysis, Zero and Poles, Bode Plots, Laplace, Fourier and Z-transforms. Time and frequency domain responses. Image impedance and passive filters. Two-port Network Parameters. Transfer functions, Signal representation. State variable method of circuit analysis, AC circuit analysis, Transient analysis. Logic families, flip-flops, Gates, Boolean algebra and minimization techniques, Multivibrators and clock circuits, Counters-Ring, Ripple. Synchronous, Asynchronous, Up and down shift registers, multiplexers and demultiplexers, Arithmetic circuits, Memories, A/D and D/A converters.Modulation index, frequency spectrum, generation of AM (balanced modulator, collector modulator), Amplitude Demodulation (diode detector Other forms of AM: Double side band suppressed carrier, DSBSC generation (balanced modulator), Single side band suppressed carrier, SSBSC generation and Phase modulation, modulation index

Unit-III

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Scalar and Vector potentials, Maxwell equations. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction.

Unit-IV

Bravais lattices. Miller indices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Diamagnetism, Paramagnetism, Ferromagnetism, Ferrimagnetism, Anti-ferromagnetism. Dielectric Materials; Types of Polarization; Piezoelectricity, Pyroelectricity and Ferroelectricity.

For any other details please check website www.jnu.ac.in/SCNS/

Ph.D.

Sl. No.	Name of Centre	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination	Pattern of Examination
1	Special Centre for Nano Sciences	Nano Sciences – NNSH (908)	**Syllabus for JNU entrance exam to Ph.D. in Nanoscience** **Part A: Research Methodology:** Numerical Ability: Numerical computation, numerical estimation, numerical reasoning and data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting. Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t-test; Analysis of variance; Elementary physics, chemistry, biology, mathematics. Opto-electronic devices (solar cells, photo-detectors, LEDs). A/D and D/A converters. Microscopy techniques. Resolving powers of different microscopes. Spectroscopy techniques. UV/visible, fluorescence, NMR spectroscopy, different types of mass spectrometry and surface plasma resonance methods Part B: Stream I: (Physical science) Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigen value problems (particle in a box, harmonic oscillator). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Scalar and Vector potentials, Maxwell equations. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. The first and second laws of thermodynamics, Thermodynamic functions, heat capacity, enthalpy, entropy. Bravais lattices. Miller indices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Diamagnetism, Paramagnetism, Ferromagnetism, Ferrimagnetism, Anti-ferromagnetism. Dielectric Materials; Types of Polarization; Piezoelectricity, Pyroelectricity and Ferroelectricity. Stream II: (Biological science) **Unit-I: Biomolecules and their interactions:** Composition, structure, function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins), Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.), Principles of biophysical chemistry (Michaelis Menten equation, pH, buffer, reaction kinetics, thermodynamics, colligative properties), Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers, Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation and isozymes, Conformation and stability of nucleic acids and proteins, Metabolism of carbohydrates, lipids, amino acids, nucleotides and vitamins and diseases associated with metabolism defects. **Unit-II: Cell Biology and cell communication:** Basic structure of cells in prokaryotes and eukaryotes, biological Membrane (structure and function); Structural organization and function of intracellular organelles; Cell growth and division, cell cycle, cytoskeleton,, intercellular communication and associated signalling pathways (hormones and their receptors, cell surface receptor, signal transduction pathways, bacteria and plant component systems) **Unit-III: Fundamental Processes:** Lipid synthesis and degradation, DNA replication, repair and recombination, RNA synthesis and processing, and protein synthesis, protein sorting and diseases. **Unit-IV :Immunology:** Innate and adaptive immunity (determinants, cellular and molecular mediators and signalling pathways), antigens, antigenicity and immunogenicity, B and T cell epitopes, structure and function of antibody molecules. Monoclonal antibodies, antigen-antibody interactions, humoral and cell-mediated immune responses, the complement system, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (e.g. tuberculosis), parasitic (e.g. malaria) and viral (e.g. HIV) infections, congenital and acquired immunodeficiencies, pathobiology of diseases and vaccines. **Unit V: Genetics:** Mendelian principles, concept of gene: Allele, multiple alleles, pseudoallele, complementation tests, mutation types and cause, basic structure of DNA and RNA, DNA as genetic material, chromosome (structure and functions), chromosomal basis of inheritance and chromosomal abnormalities, genetic testing and DNA fingerprinting. **Unit-VI:Plant Physiology:** Photosynthesis(Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C3, C4 and CAM pathways). Solute transport and photoassimilate translocation. **Unit VII: Human Physiology and Anatomy: General physiology and anatomy of human body, Blood and its constituents (**Blood corpuscles, blood coagulation, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis). Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all	Paper will be OBJECTIVE type

above.

Endocrine system (endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation and neuroendocrine regulation).

Unit VIII: General Microbiology: Microbes, classification, bacterial, fungal and viral structure, bacterial physiology, microbes in oral cavity and guts, pathogenic bacteria, commercially exploitable bacteria, phage, classification of microbial biochemical pathways, plasmids, bacteria for use in biosensors, bioremediation, antibiotic producing microbes, quorum sensing, biofilms, emerging infectious diseases, vaccines.

Stream III: (Engineering science)

Unit-I

Electronic Transport in semiconductor, PN Junction, Diode equation and diode equivalent circuit. Breakdown in diodes, Zener diodes, Tunnel diode, Semiconductor diodes, characteristics and equivalent circuits of BJT, JFET, MOSFET, IC fabrication-crystal growth, epitaxy, oxidation, lithography, doping, etching, isolation methods, metalization, bonding, Thin film active and passive devices.

Unit-II

Superposition, Thevenin, Norton and Maximum Power Transfer Theorems, Network elements, Network graphs, Nodal and Mesh analysis, Zero and Poles, Bode Plots, Laplace, Fourier and Z-transforms. Time and frequency domain responses. Image impedance and passive filters. Two-port Network Parameters. Transfer functions, Signal representation. State variable method of circuit analysis, AC circuit analysis, Transient analysis.

Unit-III

Rectifiers, Voltage regulated ICs and regulated power supply, Biasing of Bipolar junction transistors and JFET. Single stage amplifiers, Multistage amplifiers, Feedback in amplifiers, oscillators, function generators, multivibrators, Operational Amplifiers (OP AMP) -characteristics and Applications, Computational Applications, Integrator, Differentiator, Wave shaping circuits, F to V and V to F converters. Active filters, Schmitt trigger, Phase locked loop.

Unit-IV

Logic families, flip-flops, Gates, Boolean algebra and minimization techniques, Multivibrators and clock circuits, Counters-Ring, Ripple. Synchronous, Asynchronous, Up and down shift registers, multiplexers and demultiplexers, Arithmetic circuits, Memories, A/D and D/A converters.

Unit-V

Modulation index, frequency spectrum, generation of AM (balanced modulator, collector modulator), Amplitude Demodulation (diode detector Other forms of AM: Double side band suppressed carrier, DSBSC generation (balanced modulator), Single side band suppressed carrier, SSBSC generation (filter method, phase cancellation method, third method), SSB detection, Frequency and Phase modulation, modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM (direct and indirect methods), FM detector (slope detector)

Stream IV: (Chemical science)

Inorganic Chemistry

Chemical periodicity, Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory). Concepts of acids and bases, Hard-Soft acid base concept. Main group elements and their compounds: Allotropy, synthesis, structure and bonding. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties. Inner transition elements: spectral and magnetic properties. Organometallic compounds: synthesis, bonding and structure, and reactivity. Nuclear chemistry: nuclear reactions, fission and fusion.

Physical Chemistry

Basic principles of quantum mechanics: Postulates; operator algebra; exactly- solvable systems: particle-in-a-box and the hydrogen atom.Chemical bonding in diatomics; elementary concepts of MO and VB theories. Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Le Chatelier principle. Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities – calculations for model systems. Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications. Chemical kinetics: Empirical rate laws, order of reaction, zero order, first order, second order and pseudo order reactions, temperature dependence. Solid state: Crystal structures; Bragg's law and applications; band structure of solids. Polymer chemistry: Different classification of polymers, Molar masses and their calculations.

Organic Chemistry

IUPAC nomenclature of organic molecules. Principles of stereochemistry: isomerism in acyclic and cyclic compounds. Aromaticity: Benzenoid and non-benzenoid compounds – (4n+2) Rule. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways. Common named reactions and rearrangements – applications in organic synthesis.

For any other details please check website www.jnu.ac.in/SCNS/