examination would be conducted for "Computer Science' stream and "Microsystems" stream. Admission to the PhD Programme will be based on the merit in entrance and viva-voce examination.

Sl. No.	Name of School	Sub. Code & Sub. Code (Number)	Syllabus for Entrance Examination
1	School of Computer & Systems Sciences (SC&SS)	Computer Science - SCSH (890) Microsystems - MISH (915)	50% of the questions will be from Research Methodology and remaining from the other specified topics. **PART A** **Common Syllabus for the Computer Science and Microsystems Stream:** **Research Methodology:** Experimental Design; Fundamentals of Sampling; Data: types, quality measurement; Processing and Analysis of data; Hypothesis Testing (parametric, non-parametric), Theory of Probability. **Mathematics:** Integral and Differential Calculus, Linear Algebra, Numerical Analysis, Modern Algebra. **PART B** **Specific Syllabus for the Computer Science Stream**: Data Structures and Algorithms, Programming Languages (C, C++), Operating Systems, Discrete Mathematics, Automata Theory, Computer Architecture, Computer Networks, Database Management System. **Specific Syllabus for the Microsystems Stream**: Digital logic, electrons in solids, energy band theory, charge carriers in semiconductors, drift-diffusion theory, p-n junctions, MOS transistor, Basics of CMOS analog circuits, Basics of CMOS digital VLSI circuits, Basics of MEMS and VLSI Technology.

7. SCHOOL OF PHYSICAL SCIENCES

The pattern of JNUEE 2022-23 will be based on Multiple Choice Questions (MCQs) through Computer Based Test (CBT)

Ph.D.

Sl. No.	Name of School	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination
1	School of Physical Sciences (SPS)	Mathematical Sciences – MATH (897)	**Analysis:** The structure of the real numbers as an ordered field with the least upper bound property, archimedean property, Bolzano-Weierstrass theorem, Heine-Borel theorem, extended real number system, complex field, Euclidean spaces. Definition and examples of metric spaces, completeness, compactness, connectedness, continuous functions and related properties. Convergence of sequences in a metric space, subsequences, Cauchy sequences. Limits of functions, continuity of functions, uniform continuity, continuity and compactness, continuity and connectedness. Pointwise and uniform convergence, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, equicontinuity, Arzela-Ascoli theorem, Stone-Weierstrass theorem. Differentiation of functions of several real variables (directional derivatives, partial derivatives, differentiability and the total derivative, chain rule, Jacobian, higher derivatives, interchange of the order of differentiation, Taylor's theorem), inverse function theorem, implicit function theorem, rank theorem, differentiation of integrals. Lebesguemeausre and Lebesgue integral, convergence Theorems. **Linear Algebra:** Vector Spaces, subspaces, linear independence, bases, dimension, algebra of linear transformations, rank-nullity theorem, dual spaces, double dual, eigenvalues and eigenvectors, characteristic polynomial and minimal polynomial, Cayley-Hamilton

			theorem. Diagonalizability and digonalization, primary decomposition theorem, generalized eigenvectors, Jordan canonical form, rational canonical form. Bilinear forms, symmetric and skew-symmetric bilinear forms, groups preserving bilinear forms, reduction and classification of bilinear forms. **Algebra:** Definition and examples of groups - dihedral, symmetric and permutations groups, matrix groups such as GL(n) , SL(n) , abelian and cyclic groups, subgroups, normal subgroups, quotient groups, centralizer and normalizer of a group, Lagrange's theorem, isomorphism theorems, group actions, class equation, counting orbits, Cayley's theorem, Sylow's theorems, simplicity of alternating groups. Rings and subrings, isomorphisms, ideals, prime and maximal ideals, quotient rings, polynomial rings, unique factorization domain, principal ideal domain, Euclidean domain, Gauss's lemma, irreducibility criteria. Definition and examples of fields, extension of fields, finite and infinite extensions, algebraic and transcendental extensions, homomorpshims, isomorphisms and automorphisms, separable and normal extensions, splitting field of a polynomial, extending field morphisms, algebraic closure of a field, finite fields, cyclicity of the mulitplicative group of a finite field, Galois theory. **Complex Analysis:** Algebra of complex numbers, conjugates, modulus, argument, roots. Continuity and derivative of a function of one complex variable, holomorphic functions, Cauchy-Riemann equations, harmonic functions. Polynomial and rational functions, transcendental functions such as exponential, trigonometric and hyperbolic functions, logarithm. Paths and contours, contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, fundamental theorem of algebra, maximum modulus principle, open mapping theorem, Schwarz's lemma, Taylor series and Laurent series. Classification of singularities, orders or zeros and poles, winding number, meromorphic functions, Cauchy's residue theorem, computation of definite integrals using residue theorem, argument principle. Linear fractional transformations, conformal mappings. **Topology:** Definition and examples of topological spaces, basis and subbasis of a topological space, subspace topology, limit points, closure and interior, continuous functions, homeomorphisms, product topology, metric topology, quotient map and quotient topology. Connectedness, path-connectedness, compactness, local compactness and one point compactification. First and second countable spaces, separable spaces, separation axioms, Urysohn lemma, Tietze extension theorem, Tychonoff theorem and Stone-Čech compactification. **Functional Analysis:** Examples of normed spaces (sequence spaces: c, c0, lp spaces; function spaces: C[0, 1], C(R), Lp ([0, 1]), Lp(R)), finite dimensional normed spaces, continuous linear maps, Hahn-Banach Theorem, Hilbert spaces, inner product, linear functionals, orthonormal sets. **Research Methodology:** Elementary set theory, finite, countable and uncountable sets, logic, relations and functions, axioms. Elementary combinatorics, combinatorial probability, pigeon-hole principle, inclusion-exclusion principle. **Miscellaneous Topics:** Fundamental theorem of arithmetic, divisibility
2		Physical Sciences – PHYH (898)	**I. Mathematical Physics** Linear vector spaces. Eigen values and eigen vectors. Linear ordinary differential equations of first & second order. Special functions. Partial differential equations. Green's function. Fourier and Laplace transforms. Complex analysis: analytic functions, poles and residues, series expansion, and evaluation of integrals. **II. Classical Mechanics** Lagrangian and Hamiltonian formalism. Equations of motion. Central force problem. Conservation laws. Small oscillations and normal modes. Special theory of relativity. **III. Electromagnetic Theory** Gauss's law. Laplace and Poisson equations, boundary value problems. Ampere's law. Electromagnetic induction. Maxwell's equations. Scalar and vector potentials. Gauge invariance. Conservation laws for electromagnetic fields. Electromagnetic waves in free space. Dielectrics and conductors.

			Reflection and refraction of electromagnetic waves. Dynamics of charged particles in static and uniform electromagnetic fields. **IV. Quantum Mechanics** Wavefunctions and operators. Heisenberg uncertainty principle. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, hydrogen atom). Tunneling. Orbital and spin angular momenta. Addition of angular momenta. Time-independent perturbation theory. Variational method. Time dependent perturbation theory: Fermi's golden rule and selection rules. Identical particles and indistinguishability. V. **Thermodynamics and Statistical Physics** Laws of thermodynamics and their consequences. Thermodynamic potentials. Legendre transformation. Maxwell relations. Chemical potential, phase equilibria. Micro-canonical, canonical and grand-canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Blackbody radiation and Planck'sdistribution. First- and second-order phase transitions. **VI. Atomic & Molecular Physics** Quantum states of electrons in an atom. Relativistic corrections of atomic energy levels. LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Magnetic resonance. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules. Lasers: spontaneous and stimulated emission, Einstein A &B coefficients. Optical pumping, population inversion, rate equation. VII. **Condensed Matter Physics** Bravais lattices. Reciprocal lattice. Diffraction and structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory of metals and electronic specific heat. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Band theory of solids: metals, insulators and semiconductors. Superconductivity: Type-I and type-II superconductors. Magnetism: types of magnetic ordering and Curie-Weiss law. **VIII. Nuclear and Particle Physics** Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model. Nuclear force. Single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). **IX. Electronics** Semiconductor devices (diodes, junctions, transistors, and field effect devices), device characteristics. Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). **X. Research Methodology and Experimental Methods** Data analysis. Error estimation. Measurement of electrical resistivity, Hall coefficient, magnetic susceptibility and thermal conductivity. Interference and diffraction experiments. Spectroscopic measurements such as Zeeman effect, Electron Spin Resonance, and Raman effect. Experimental determination of fundamental constants such as Planck's constant, e/m, and Boltzmann constant.
3		Chemical Sciences – CHEH (899)	**Research Methodology** Analytical chemistry, chromatographic separation, crystallization, spectroscopic techniques, electro-and thermoanalytical methods. Data analysis: Mean and standard deviation; absolute and relative errors; linear regression; covariance and correlation coefficient. **Organic Chemistry** 1. IUPAC nomenclature of organic molecules including regio - and stereoisomers. 2. Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction. 3. Aromaticity: Benzenoid and non - benzenoid compounds – generation and reactions. 4. Organic reactive intermediates: Generation, stability and reactivity of carbocations,

			carbanions, free radicals, carbenes, benzynes and nitrenes. 5. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways. 6. Common named reactions and rearrangements – applications in organic synthesis. 7. Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio and stereoselective transformations. 8. Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups. 9. Asymmetric synthesis: Chiral auxiliaries, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions; determination of enantiomeric and diastereomeric excess; enantio-discrimination. Resolution – optical and kinetic. 10. Pericyclic reactions – electrocyclisation, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry. 11. Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S). 12. Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Biogenesis of terpenoids and alkaloids. 13. Structure determination of organic compounds by IR, UV - Vis, 1H &13C NMR and Mass spectroscopic techniques. **Inorganic Chemistry** 1. Chemical periodicity: Classification of elements and periodicity in properties. 2. Molecular Structure and Bonding: Valence bond theory, molecular orbital Theory, VSEPR theory. 3. Acids and Bases: Lewis acids and bases, HSAB concept, Gas phase versus solution acidity, Solvent levelling effects, Surface acidity. 4. Oxidation and Reduction: Analysis of redox cycles, Redox stability in water, Disproportionation/Comproportionation, Frost, Latimer and Pourbaix diagrams. 5. Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds. 6. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms. 7. Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications. 8. Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis. 9. Cages and metal clusters. 10. Bioinorganic chemistry: photosystems, porphyrins, metalloenzymes, oxygen transport, electron-transfer reactions; nitrogen fixation, metal complexes in medicine. 11. Nuclear chemistry: nuclear reactions, fission and fusion, radio- analytical techniques, activation analysis, principles of determination of age of rocks and minerals, and Radio-carbon dating. 12. Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques. **Physical Chemistry** 1. Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunnelling. 2. Approximate methods of quantum mechanics: Variational principle; perturbation theory up to second order in energy; applications. 3. Atomic structure and spectroscopy; term symbols; many-electron systems and antisymmetry principle. 4. Chemical bonding in diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems. 5. Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules. 6. Molecular spectroscopy: Rotational and vibrational spectra of diatomic molecules; electronic spectra; IR and Raman activities – selection rules; basic principles of magnetic resonance. 7. Chemical thermodynamics: Laws, state and path functions and their applications;

			thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions. 8. Statistical thermodynamics: Boltzmann distribution; kinetic theory of gases; partition functions and their relation to thermodynamic quantities–calculations for model systems. 9. Electrochemistry: Nernst equation, redox systems, electrochemical cells; Debye-Huckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations. 10. Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions. 11. Colloids and surfaces: Stability and properties of colloids; isotherms and surface area; heterogeneous catalysis. 12. Solid state: Crystal structures; Bragg's law and applications; band structure of solids. 13. Polymer chemistry: Molar masses; kinetics of polymerization.

8. SCHOOL OF COMPUTATIONAL AND INTERGRATIVE SCIENCES

The pattern of JNUEE 2022-23 will be based on Multiple Choice Questions (MCQs) through Computer Based Test (CBT)

Ph.D.

Sl. No.	Name of School	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination
1	School of Computational and Integrative Sciences (SC&IS)	Computational Biology and Bioinformatics – Track 1 – TROH (903); Track 2 – TRTH (909) & Track 3 – TRDH (910)	(Separate merit lists of students for Track 1 (Physical sciences), Track 2 (Biological Sciences) and Track 3 (Mathematical and Computer sciences) will be used for final admissions. The categorization in Tracks will be based on students' choice in the application form depending on his/her academic background. The Ph.D course will have a single entrance test with the following break up. Part A: General reasoning, Part B: Subject specific, comprising six sections. The syllabus for respective sections is as follows: Part A: General Reasoning This part of the question paper is to assess the analytical and quantitative skills of the students acquired throughout their academic career. Part B: This part of the question paper is to assess the domain knowledge of the students. It comprises six sections corresponding to six different disciplines, namely physics, chemistry, bioinformatics, life sciences, mathematics, and computer science that are further categorized into three tracks as below. Track 1: Physics, Chemistry