			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

			Track 2: Bioinformatics, Life Science Track 3: Mathematics, Computer Science Students are required to attempt a total of two sections out of the six available, among which at least one section from the chosen track is mandatory. **Section 1: Physics:** Mathematical Physics: Linear vector space; matrices; vector calculus; linear differential equations; elements of complex analysis; Laplace transforms, Fourier analysis, elementary ideas about tensors. Classical Mechanics: Conservation laws; central forces, Kepler problem and planetary motion; collisions and scattering in laboratory and Centre of mass frames; mechanics of system of particles; rigid body dynamics; moment of inertia tensor; noninertial frames and pseudo forces; variational principle; Lagrange's and Hamilton's formalisms; equations of motion, cyclic coordinates, Poisson bracket; periodic motion, small oscillations, normal modes; special theory of relativity – Lorentz transformations, relativistic kinematics, mass- energy equivalence. Electromagnetic Theory: Solution of electrostatic and magnetostatic problems including boundary value problems; dielectrics and conductors; Biot-Savart's and Ampere's laws; Faraday's law; Maxwell's equations; scalar and vector potentials; Coulomb and Lorentz gauges; Electromagnetic waves and their reflection, refraction, interference, diffraction and polarization. Poynting vector, Poynting theorem, energy and momentum of electromagnetic waves; radiation from a moving charge. Quantum Mechanics: Physical basis of quantum mechanics; uncertainty principle; Schrodinger equation; one, two and three dimensional potential problems; particle in a box, harmonic oscillator, hydrogen atom; linear vectors and operators in Hilbert space; angular momentum and spin; addition of angular momenta; time independent perturbation theory; elementary scattering theory. Thermodynamics and Statistical Physics: Laws of thermodynamics; macrostates and microstates; phase space; probability ensembles; partition function, free energy, calculation of thermodynamic quantities; classical and quantum statistics; degenerate Fermi gas; black body radiation and Planck's distribution law; Bose-Einstein condensation; first and second order phase transitions, critical point. Atomic and Molecular Physics: Spectra of one- and many-electron atoms; LS and jj coupling; hyperfine structure; Zeeman and Stark effects; electric dipole transitions and selection rules; X-ray spectra; rotational and vibrational spectra of diatomic molecules; electronic transition in diatomic molecules, Franck- Condon principle; Raman effect; NMR and ESR; lasers. **Section 2: Chemistry:** Organic Chemistry, Stereochemistry Properties of gases, kinetic theory Thermodynamics Chemical Bonding, Oxidation states, electrochemistry Molecular Structure, spectroscopy Chemical Kinetics Quantum Mechanics Statistical Mechanics **Section 3: Life Sciences/Biotechnology** Biomolecules & Cellular Organization, Fundamental Processes, Basic Concepts in Genetics & Immunology, Developmental Processes, Genome Structure & Organization, Gene Expression and Regulation, Basic Techniques in Molecular Biology and Recombinant DNA Technology

			Section 4: Bioinformatics Sequence analysis and alignment algorithms, Phylogenetic Analysis, Databases, Sequencing Technologies, Structural Bioinformatics, Concepts in sequence analysis, Genomics and Transcriptomics, Sequencing methods, Sequence formats, Methods of gene expression profiling, Genetic/epigenetic variations **Section 5: Mathematics** Hydrodynamics: Classification of fluids, the continuum model, Lagrangian and Eulerian approach of description. Lagrangian and Eulerian methods. Equation of continuity. Boundary surface. Stream lines. Path lines and streak lines. Velocity potential. Irrotational and rotational motions. Vortex lines, vorticity vector, equi-potential surface streamlines, pathlines, Mass flux density, conservation of mass leading to equation of continuity, conservation of momentum and its mathematical formulation, Lagrange's and Euler's equations of motion, Bernoulli's theorem, Equation of motion by flux method. Equations referred to moving axes, Impulsive actions, Stream function. Viscous flow, stress and strain analysis, stokes hypothesis, The Navier-stokes equation of motion, Poiseuille flow. Advanced Differential Equations: Existence and uniqueness theorem, Sturm comparison and separation theorem, homogeneous linear system, Nonhomogeneous linear system, linear system with constant coefficient. Two-point boundary value problems, Green function, Construction of green function, Sturm-Liouville system, Non-linear Differential Equation, Solution of PDEs by method of integral transforms (Laplace and Fourier), Boundary value problem, Maxima and minimum principles, Uniqueness and continuity Theorem. Special Function: Calculus of Variation-Functional and its properties, Variational problems with fixed boundaries, Legendre polynomial and functions, Christoffel's summation formula, Bessel's Function, Modified Bessel's function, Bessel's equations. Hermite polynomials, Laguerre polynomials. Linear Algebra: Vector spaces, Sub spaces, linearly dependent & linearly independent vectors, Basis, Dimension, linear transformation, Matrix representation of a linear transformation, Rank & Nullity theorem. Finite dimensional vector spaces, Existence theorem for basis, Quotient space and its dimension. Rank of a matrix, Eigen values & Eigen vectors. Change of basis, Canonical forms, Diagonal forms, Triangular forms, Jordan forms, Quadratic forms, reduction and classification of quadratic forms, Orthogonal transformations, Unitary transformations, Positive semi definite matrices, Semi definite matrices. Operational Research and Networking: Introduction to Linear Programming. Problem formulations. Linear independence and dependence of vectors. Convex sets. Extreme points. Hyperplanes and Half spaces. Directions of a convex set. Convex cones. Polyhedral sets and cones. Theory of Simplex Method. Simplex Algorithm. Transportation problem. Assignment problem. Graph Theory and Petri nets: Selected topics in graph theory: basic definitions and notions, characterization of trees, vector vacuum of a graph, planarity of graphs, Hamiltonian and Eulerian cycles. Edge – and vertex colourings of graphs: chromatic number, chromatic index, map colour theorem, four – colour problem. Independence theory in combinatory. Directed digraphs. Flow networks. Applications. Petri nets and their types. Probability and Statistics: Measures of central tendency and dispersion, Skewness and kurtosis, Probability, Conditional probability, Theorem of total probabilities, Bayes theorem, Random variables, Probability mass and density functions, Mathematical expectation and its properties, Moment generating functions, Binomial, Poisson, Geometric, Exponential and Normal distributions and their properties, Method of least squares, Correlation and regression. **Section 6: Computer Science and Programming** Computer Organization and Architecture Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

			Programming and Data Structures Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs. Algorithms Searching, sorting, hashing. Asymptotic worst case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph search, minimum spanning trees, shortest paths. Theory of Computation Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and contex-free languages, pumping lemma. Turing machines and undecidability. Compiler Design Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation. Operating System Processes, threads, inter-process communication, concurrency and synchronization. Deadlock. CPU scheduling. Memory management and virtual memory. File systems. Databases ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control. Computer Networks Concept of layering. LAN technologies (Ethernet). Flow and error control techniques, switching. IPv4/IPv6, routers and routing algorithms (distance vector, link state). TCP/UDP and sockets, congestion control. Application layer protocols (DNS, SMTP, POP, FTP, HTTP). Basics of Wi-Fi. Network security: authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls.

9. SCHOOL OF ARTS & AESTHETICS

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 Arts & Aesthetics (SA&A)	**Ph.D. :** Visual Studies – VSAH (900)	Note: The programme is suited for students who come from a background in Visual Studies/ Art History and related disciplines. Candidates are expected to already be familiar with the discipline of art history and its theoretical concerns in general and with the development of Indian art and architecture in particular. To appear for the entrance exam, prospective candidates should have a broad understanding of the intellectual history of the discipline and key philosophical concerns of image theories. They should be familiar with the topics listed below which are areas covered by Masters-level programmes. Questions set by the School are designed to assess the candidate's ability to reflect upon and critically engage with themes and issues related to art and visual culture. Candidates appearing for the entrance examination should be familiar with the following: