8. SCHOOL OF COMPUTATIONAL AND INTERGRATIVE SCIENCES

The pattern of JNUEE 2020-21 will be based on Multiple Choice Questions (MCQs) through Computer Based Test (CBT)

M.Sc. Programme

Sl. No.	Name of Centre	Sub. Code & Sub. Code (Number)	Syllabus for Entrance Examination
1	School of Computational and Integrative Sciences (SC&IS)	Computational and Integrative Sciences - Track 1 – TROM (232) & Track 2 – TRTM (238)	**Section 1: Physics** **Mathematical Physics:** Linear vector space; matrices; vector calculus; linear differential equations; Fourier analysis. **Classical Mechanics:** Conservation laws; central forces, Kepler problem and planetary motion; mechanics of a system of particles; rigid body dynamics; moment of inertia tensor; special theory of relativity – Lorentz transformations, 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; Electromagnetic waves and their reflection, refraction, interference. Poynting vector, Poynting theorem. **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. **Thermodynamics and Statistical Physics:** Laws of thermodynamics; macrostates and microstates; phase space; free energy, calculation of thermodynamic quantities; black body radiation and Planck's distribution law; classical statistics. **Atomic and Molecular Physics:** Spectra of one- and many-electron atoms; LS and jj coupling; Zeeman and Stark effects; X-ray spectra; lasers. **Section 2:Chemistry:** General Topics(Inorganic and Basic Organic) Properties of gases, kinetic theory Thermodynamics Chemical Bonding Molecular Structure Chemical Kinetics **Section 3: Mathematics/Statistics:** General topics at the B.Sc. level. Specific focus will be on the following topics: **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. **Abstract Algebra:** Divisibility in the set of integers, congruence, Groups, Sub groups, Permutation groups, Cyclic groups, Lagrange's theorem and its consequences, Normal subgroups, Quotient groups, Group homomorphism, Kernel of a homomorphism, Fundamental

			theorem of homomorphism of groups, Group isomorphism, Cayley's theorem. **Optimization:** 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. Assignment and Transportation. Calculus, Differential Calculus, Vector Calculus, Numerical Analysis, Mechanics, Mathematical Methods, Real Analysis **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 4: <u>Computer Sciences and Programming:</u>** Questions will be set at the B.Tech/M.Tech Level. Special Focus will be on the following topics **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 context-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. **Section 5: Life Sciences** Biomolecules & Cellular Organization, Fundamental Processes: Replication, Transcription and Translation, Basic Concepts in Genetics & Immunology, Genome Organization & Regulation, Basic Techniques in Molecular Biology and Recombinant DNA Technology **Section 6: Biotechnology/ Bioinformatics** Sequence analysis and alignment algorithms, Phylogenetic Analysis, Fundamentals of Genomics, Structural Bioinformatics, Basic concepts in molecular biology, genetics and biochemistry.

Post-Graduate Diploma in Big Data Analytics (PGDT)

Sl. No.	Name of Centre	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination
1	School of Computational and Integrative Sciences (SC&IS)	Post-Graduate Diploma in Big Data Analytics – PGDT (191)	(Separate merit lists of students for Track 1 (Non-biological sciences) and Track 2 (Biological sciences) will be used for final admissions. The categorization in Tracks will be based on students' choice in the application form irrespective of his/her academic background and section of questions he/she attempts. Total number of seats will be equally divided into the two tracks) PG Diploma course will have a single entrance test of **Data Science Aptitude (Biological data)** with the following break up. General reasoning, Computer programming in Python and C, Basic statistics, Bioinformatics/ Life Science, **The syllabus for respective sections is as follows:** **1. General Reasoning** This section is designed to assess the analytical and quantitative skills of the students acquired throughout their academic career. **2. Computer programming in Python and C** Fundamentals of Programming in Python: File handling. Basic python libraries. Functions. Loops. Numerical functions in python. Basic operations in Python for matrices, algebra, numerical and string manipulations. Regular expressions and text processing. Fundamentals of C programming: Loops. Data types. Arrays. Libraries. Functions. I/O functions. Pointers and Structures. **3. Basic statistics** General aspects: Randomness. Randomization. Random number generation. Statistical dispersion. Observational error. Central tendencies. Mean, median, mode. Relative frequency. Variance. Standard deviation. Maximum likelihood. Bayesian probability. Information entropy. Foundations of probability theory. Probability theory. Standard probability space. Normalizing constant. Event and Complementary event. Mutually exclusive events. Probability density function. Cumulative distribution function. Bayes theorem. Prior probability. Posterior probability. Random variables, Statistical independence. Conditional independence. Pairwise independence. Covariance and Correlation. Theory of probability distributions. Probability distribution. Probability distribution function. Probability density function. Quantile. Moment about the mean. Standardized moment. Skewness. Kurtosis. Properties of probability distributions. Normal distribution. Poisson distribution. Binomial distribution. **4. Bioinformatics/Life Sciences** Sequence analysis and alignment, Phylogenetic Analysis, Database Management System, Structural bioinformatics & drug designing, Databases and tools for biological data mining and pathway analysis, Biomolecules & Cellular Organization, Fundamental Processes: Replication, Transcription and Translation, Gene structure, Transcriptional and post-transcriptional Gene Regulation, Genome Organization, Metabolic engineering and Systems Biology, gene regulatory networks, Basic Techniques in Molecular Biology, Fundamentals of Genomics, transcriptomics, proteomics and metabolomics, Next Generation Sequencing Technologies and data analysis

Ph.D.

Sl. No.	Name of Centre	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)	**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: Mathematics/Statistics:** **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 4: 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. **Section 5: <u>Life Sciences/Biotechnology</u>** 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 6: <u>Bioinformatics</u>** Sequence analysis and alignment algorithms, Phylogenetic Analysis, Sequencing Technologies, Structural Bioinformatics, Advanced concepts in sequence analysis, Genomics and Transcriptomics **Section 7 Electronics Engineering** **Networks, Signals and Systems** Network solution methods: nodal and mesh analysis; Network theorems: superposition, Thevenin and Norton's, maximum power transfer; Steady state sinusoidal analysis using phasors; Time domain analysis of simple linear circuits, Laplace transform, Linear 2-port network parameters: driving point and transfer functions. Continuous-time signals: Fourier series and Fourier transform representations, sampling theorem and applications; Discrete-time signals, Z-transform, LTI systems: definition and properties, causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure. **Electronic Devices** Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; Generation and recombination of carriers; Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET, LED, photo diode, Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography. **Analog Circuits** BJTs and MOSFETs; Simple diode circuits: clipping, clamping and rectifiers; Single-stage BJT and MOSFET amplifiers: biasing, bias stability, BJT and MOSFET amplifiers: multi-stage, differential, feedback, power and operational; Simple op-amp circuits; Active filters; Sinusoidal oscillators: criterion for oscillation, single-transistor and opamp configurations; Function generators, wave-shaping circuits and 555 timers. **Digital Circuits** Number systems; Combinatorial circuits: Boolean algebra, minimization of functions using Boolean identities and Karnaugh map, logic gates, arithmetic circuits, code converters, multiplexers, decoders, Sequential circuits: latches and flip-flops, counters, shift-registers, Data converters: sample and hold circuits, ADCs and DACs; Semiconductor memories: ROM, SRAM, DRAM; 8-bit microprocessor (8085): architecture, programming, memory and I/O interfacing. **Communications** Analog communications: amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, superheterodyne receivers, Information theory: entropy, mutual information and channel capacity theorem ; Digital communications: PCM, DPCM, digital modulation schemes, amplitude, phase and frequency shift keying (ASK, PSK, FSK), QAM, calculation of bandwidth, SNR and BER for digital modulation; Fundamentals of error correction, Hamming codes; Timing and frequency synchronization, inter-symbol interference and its mitigation; Basics of TDMA, FDMA and CDMA. **Satellite communication:** Introduction, need, satellite orbits, advantages and disadvantages of geostationary satellites. Satellite visibility, satellite system – space segment, block diagrams of satellite sub systems, up link, down link, cross link, transponders (C- Band) **Local area networks (LAN):** Primary characteristics of Ethernet-mobile IP, OSI model, wireless LAN requirements-concept of Bluetooth, Wi-Fi and WiMAX. **Electromagnetics** Electrostatics; Maxwell's equations: differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector; Plane waves and properties: reflection and refraction, polarization, phase and group velocity, propagation through various media, skin depth; Transmission lines: equations, characteristic impedance, impedance matching, impedance transformation, S-parameters, Smith chart; Waveguides: modes, boundary conditions, cut-off frequencies, dispersion relations; Antennas: antenna types, radiation pattern, gain and directivity, return loss, antenna arrays; Basics of radar; Light propagation in optical fibers.

			Microwave and Antennas Introduction & Wave Propagation Review of Maxwell's equations, Integral and Point forms; Boundary conditions; Power flow and Poynting vector; Propagation of uniform plane waves, Wave equation; Polarization. Scalar and Vector Potential functions, Retarded Potentials; Radiation phenomenon and equation, Basic antenna parameters: radiation resistance, Gain, directivity, Effective length, Radiation pattern; Radiation from short current element, Radiation from small current loop, radiation from arbitrary current distribution, half wave dipole antenna; Antenna impedance, Monopole antenna, Baluns, Antenna array: Broadside array and end-fire arrays, long wire antenna; Few antenna types: Folded dipole, Loop antenna, Yagi-Uda Antenna; Wave propagation, Travelling waves, Lossless and Lossy transmission lines, pulse propagation; Principle, construction and working of Microwave solid state devices: Transferred Electron devices: Gunn Diode (Gunn Effect), IMPATT diode, PIN diode Attenuators, Terminators, Directional couplers; Hybrid Circuits

9. SCHOOL OF ARTS & AESTHETICS

The pattern of JNUEE 2020-21 will be based on Multiple Choice Questions (MCQs) through Computer Based Test (CBT)

Master of Arts

Sl. No.	Name of Centre	Sub. Code & Sub. Code Number	Syllabus for Entrance Examination
1	School of Arts & Aesthetics (SA&A)	Arts & Aesthetics-SAAM (235)	Note: Candidates attempting the entrance exam of the integrated MA should have a broad sense of the areas listed under all the three streams of the School – Visual Studies, Cinema Studies and Theatre and Performance Studies. Questions set by the School typically ask questions that assess the candidate's ability to reflect upon and critically engage with themes and issues related to art. **Visual Studies** Broad knowledge of the history of world art in general, and of art in South Asia, from Indus Valley Civilization till the present, in particular. Candidates should have an understanding of formal, stylistic and iconographic aspects of South Asian art and be able to place them in their literary, cultural, historical, religious and liturgical context. In addition, a broad knowledge of the history of Western Art, from the Renaissance to the present day, and of the history of Asian art, including Far Eastern and Islamic art, are valuable. An awareness of current debates and new developments around art, heritage, museums and exhibitions is important, with an emphasis on the ability to critically engage with issues and themes related to art. **Cinema Studies** Broad knowledge of World Cinema, Film Movements, and Film/Media Practitioners. There should be awareness of cinema/ media's status as an aesthetic practice, a mass cultural form, and an instigator of public debates. Candidates should display their knowledge of the public presence of cinema/media and the way certain film practices get linked to political controversies, festival bans, censorship debates, and vandalism at exhibition venues. Some knowledge of the role of film criticism and writing about cinema in the popular press will be helpful. **Theatre and Performance Studies** Broad knowledge of the history of theatre and dance including classical Greek theatre, Elizabethan theatre, classical Indian theatre, music, dance and performance cultures, *bhakti* performance traditions in India, modern theatre and contemporary performance practices. Some familiarity with dance in the larger context of Indian dance history, relationship of dance and society. Likewise, an engagement with musical traditions, both classical and popular. Some awareness of basic concepts like *rasa* and catharsis, the dynamics of body, space and time in different theatrical and dance traditions, the role of the actor/performer and