Module for B.Sc. Mathematics Honours

Academic Year 2022 – 2023 (Odd Semester)

1. Module for Semester – I (New CBCS Syllabus w.e.f. 2022 – 2023):

Name of the Teacher	Duration	Course
Dr. Mridula Sarkar	July – September, 2022	**<u>Core– I (Calculus, Geometry, Differential Equation)</u>** *Unit – I*: Higher order derivatives, Leibnitz rule and its applications to problems of type $e_{ax}+ b \sin x$,$e_{ax}+ b \cos x$, $(ax + b)_n \sin x$, $(ax + b)_n \cos x$, Arc length, Derivative of arc length (Cartesianand Polar), Pedal equation, Curvature, Radius of curvature, Centre of curvature [12L]
	October – December, 2022	concavity,convexity and inflection points, envelopes, asymptotes (Cartesian), Singular points,Classification of double points, curve tracing in Cartesian and polar coordinate systems,Indeterminate forms: L'Hospital's rule. [8L]
Sri Uttam Kr. Mahanty	July – September, 2022	*Unit II:* Reduction formulae, derivations and illustrations of reduction formulae of the type $\int sinnxdx$, $\int cosnxdx$, $\int tannxdx$, $\int secnxdx$, $\int (logx)_n dx$, $\int \sin nx \sin mxdx$. [12L]
	October – December, 2022	Area under Cartesian and Polar curves, parametric equations, parameterizing of a curve, arclength, arc length of parametric curves, area and volume of surface of revolutions. [8L]
Dr. SamiranKarmakar	July – September, 2022	*Unit III*: Reflection properties of conics, Transformation of axes and second-degree equations,Invariants, classification of conics using the discriminant, Pair of straight lines, polar equationsof straight lines, circles and conics. Spheres, Cone, Cylindrical surfaces. Central conicoids, paraboloids, plane sections ofconicoids, Tangent, Normal, Enveloping Cone and Cylinder, Generating lines, classification ofquadrics, Transformation of axes in space and general equation of second degree. [6L]
	October – December, 2022	*Unit IV* Product of three or more vectors, Applications in Geometry, introduction to vector functions ofone independent variable, operations with vector-valued functions of one independent variable,limits and continuity of vector functions, differentiation and integration of vector

		functions of one independent variable. [4L]
Sri UtpalBadyakar	July – September, 2022	**<u>Core – II (Algebra)</u>** *Unit I:* Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rationalindices and its applications. Theory of equations: Relation between roots and coefficients, Transformation of equation,Location of roots: Descartes rule of signs, Sturm's theorem, Cubic and biquadratic equation,Cardon's, Ferrai's and Euler's method. Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality. [12L]
	October – December, 2022	Equivalence relations, partial order relation, poset, linear order relation. Well-orderingproperty of positive integers, Division algorithm, Divisibility and Euclidean algorithm. Primenumbers and their properties, Euclid's theorem. Congruence relation between integers. Principles ofMathematical Induction, statement of Fundamental Theorem of Arithmetic. [8L]
Dr. Swapan Mukhopadhyay	July – September, 2022	*Unit III* Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. [8L]
	October – December, 2022	Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n, rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix. Cayley-Hamilton theorem and its use in finding the inverse of a matrix. [5L]

2. Module for Semester – III (CBCS Syllabus under Bankura University):

Name of the Teacher	Duration	Course
Dr. Swapan Mukhopadhyay	July – September, 2022	**<u>CoreV</u> (Theory of Real Functions & Introduction to Metric Space)** *Unit – I*: Limits of functions (ε - δ approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.

		Unit II: Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum theorem. Rolle's theorem. Mean value theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials [12L]
	October – December, 2022	*Unit III* Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, $\ln(1 + x)$, $1/ax+b$ and $(1 +x)^n$. Application of Taylor's theorem to inequalities. *Unit IV* Metric spaces: Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces. [8L]
Sri UtpalBadyakar	July – September, 2022	**<u>CoreVI (</u>Group Theory I)** *Unit – I*: Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (through matrices), elementary properties of groups. *Unit II*: Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. [12L]
	October – December, 2022	*Unit - III* Properties of cyclic groups, classification of subgroups of cyclic groups. Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange's theorem and consequences including Fermat's Little theorem. *Unit IV* External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy's theorem for finite abelian groups. *Unit V* Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms. First, Second and Third isomorphism theorems.
Ms. Mridula Sarkar	July – September, 2022	**<u>Core VII (</u>Numerical Models)** *Unit I*: Algorithms. Convergence. Errors: Relative, Absolute. Round off. Truncation.

		Unit II: Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method, Regula-falsi method, fixed point iteration, Newton-Raphson method. Rate of convergence of these methods. *Unit III*: System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. LU Decomposition. *Unit IV* Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation. Numerical differentiation: Methods based on interpolations; methods based on finite differences. [6L]
	October – December, 2022	*Unit V* Numerical Integration: Newton Cotes formula, Trapezoidal rule, Simpson's 1/3rd rule, Simpsons 3/8th rule, Weddle's rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's 1/3rd rule, Gauss quadrature formula. The algebraic eigenvalue problem: Power method. Approximation: Least square polynomial approximation. *Unit VI* Ordinary Differential Equations: The method of successive approximations, Euler's method, the modified Euler method, Runge-Kutta methods of orders two and four. [4L]
Dr. SamiranKarmakar	July – September, 2022	**<u>SEC - I (C Programming)</u>** *Unit I:* Programming paradigms, characteristics of object-oriented programming languages, brief history of C, structure of C program, differences between C and C++, basic C operators, Comments, working with variables, enumeration, arrays and pointer. [12L]
	October – December, 2022	*Unit II* Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators. *Unit III* Template class in C, copy constructor, subscript and function call operator, concept of namespace and exception handling.

Module for ***Computer Aided Numerical Methods –Practical:***

Students are divided into two groups and three teachers are allotted for these groups:

I) Group A: Dr. SamiranKarmakar
II) Group B: Dr. Mridula Sarkar

August – September, 2022	Prerequisites: PC – operating system, Basics of C Compiler Dev C++, Compilation, Run Commends. 1. Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N. 2. Enter 100 integers into an array and sort them in an ascending order. 3. Finding a real Root of an equation byNewton-Rapson's method.
October – December, 2022	5. Interpolation (Taking at least six points) by Lagrange's formula 6. Integration by (i) Trapezoidal rule (ii) Simpson's 1/3rd rule (taking at least 10 sub-intervals) 7. Solution of a 1st order ordinary differential equation by fourth-order R. K. Method, taking at least four steps. [30L]

3. Module for Semester – V (CBCS Syllabus under Bankura University):

Name of the Teacher	Duration	Course
Dr. Mridula Sarkar	July – September, 2022	**Core XI (Partial Differential Equations and Applications)** *Unit – I*: Partial Differential Equations – Basic concepts and Definitions. Mathematical Problems. First- Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations. *Unit II*: Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms. [12L]
	October – December, 2022	*Unit III* The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of an infinite string. Initial Boundary Value Problems. Semi-Infinite String with a fixed end, Semi-Infinite String with a Free end. Equations with non-homogeneous boundary conditions. Non-Homogeneous Wave Equation. Method of separation of variables, Solving the Vibrating String Problem. Solving the Heat Conduction problem *Unit IV*

		Central force. Constrained motion, varying mass, tangent and normal components of acceleration, modelling ballistics and planetary motion, Kepler's second law. [8L]
Sri UtpalBadyakar	July – September, 2022	**Core XII (Group Theory II)** *Unit – I*: Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties. *Unit II*: Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups. [12L]
	October – December, 2022	*Unit - III* Group actions, stabilizers and kernels, permutation representation associated with a given group action. Applications of group actions. Generalized Cayley's theorem. Index theorem. *Unit IV* Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn, p-groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests.
Dr. Swapan Mukhopadhyay	July – September, 2022	**DSE 1 (Linear Programming)** *Unit I*: Introduction to linear programming problem. Theory of simplex method, graphical solution, convex sets, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method. Big-M method and their comparison. *Unit II*: Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem. [6L]
	October – December, 2022	*Unit II* assignment problem and its mathematical formulation, Hungarian method for solving assignment problem. *Unit IV* Game theory: formulation of two-person zero sum games, solving two-person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games. [4L]

Dr. SamiranKarmakar	July – September, 2022	**DSE 2 (Probability and Statistics)** *Unit I:* Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. *Unit II:* Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables. [12L]
	October – December, 2022	*Unit III* Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central Limit theorem for independent and identically distributed random variables with finite variance, Markov Chains, Chapman-Kolmogorov equations, classification of states. *Unit III* Random Samples, Sampling Distributions, Estimation of parameters, Testing of hypothesis.