Module for B.Sc. Mathematics Honours

Academic Year 2018 – 2019

1. Module for Semester – I (New CBCS Syllabus under Bankura University):

Name of the Teacher	Duration	Course
Dr. SamiranKarmakar	July – September, 2018	**Core– I (Calculus, Geometry, Differential Equation)** *Unit – I*: Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problems of type $e^{ax}+b\sin x$, $e^{ax}+b\cos x$, $(ax+b)n\sin x$, $(ax+b)n\cos x$, concavity and inflection points, envelopes, asymptotes. [12L]
	October – December, 2018	curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L' Hospital's rule, applications in business, economics and life sciences. [8L]
Sri Uttam Kr. Mahanty	July – September, 2018	*Unit II:* Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx dx$, $\int \cos nx\, dx$, $\int \tan nx\, dx$, $\int \sec nx\, dx$, $\int (\log x)^n dx$, $\int \sin nx \sin mx\, dx$, parametric equations, parameterizing a curve. [12L]
	October – December, 2018	Arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics. [8L]
Ms. Mridula Sarkar	July – September, 2018	*Unit III*: Reflection properties of conics, rotation of axes and second-degree equations, classification of conics using the discriminant, polar equations of conics. Spheres. Cylindrical surfaces. Central conicoids, paraboloids, plane sections of conicoids, Generating lines, classification of quadrics, Illustrations of graphing standard quadric surfaces like cone, ellipsoid. [6L]
	October – December, 2018	*Unit IV* Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations. [4L]
Sri UtpalBadyakar	July – September, 2018	**Core – II (Algebra)** *Unit I:* Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.

		Theory of equations: Relation between roots and coefficients, Transformation of equation, Descartes rule of signs, Cubic and biquadratic equation. Inequality: The inequality involving AM≥GM≥HM, Cauchy-Schwartz inequality. [12L]
	October – December, 2018	Equivalence relations. Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set. Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm. Congruence relation between integers. Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic. [8L]
Dr. Swapan Mukhopadhyay	July – September, 2018	*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, 2018	Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of Rn, dimension of subspaces of Rn, 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 – II (New CBCS Syllabus under Bankura University):

Name of the Teacher	Duration	Course
Dr. Swapan Mukhopadhyay	January – March, 2019	**<u>Core– III (Real Analysis)</u>** *Unit – I*: Review of Algebraic and Order Properties of R, ε-neighbourhood of a point in R. Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets. Suprema and Infima. Completeness Property of R and its equivalent properties. [12L]
	April – June, 2019	The Archimedean Property, Density of Rational (and Irrational) numbers in R, Intervals. Limit points of a set, Isolated points, Open set, closed set, derived set, Illustrations of Bolzano-Weierstrass theorem for sets, compact sets in R, Heine-Borel Theorem. [8L]
Sri UtpalBadyakar	January – March, 2019	*Unit II:* Sequences, Bounded sequence, Convergent sequence, Limit of a sequence, lim inf, lim sup. Limit Theorems. Monotone Sequences,

		Monotone Convergence Theorem. Subsequences, Divergence Criteria. Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion. [12L]
	April – June, 2019	*Unit III* Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test. Alternating series, Leibniz test. Absolute and Conditional convergence. [8L]
Dr. Mridula Sarkar	January – March, 2019	**Core – IV (Differential Equations and Vector Calculus)** *Unit I:* Lipschitz condition and Picard's Theorem (Statement only). General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications. [12L]
	April – June, 2019	Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters. [8L]
Dr. SamiranKarmakar	January – March, 2019	*Unit II* Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients. Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. [8L]
	April – June, 2019	*Unit III* Equilibrium points, Interpretation of the phase plane. Power series solution of a differential equation about an ordinary point, solution about a regular singular point. [15L]
Mr. Uttam Kr. Mahanty	January – March, 2019	*Unit IV* Triple product, introduction to vector functions, operations with vector-valued functions.
	April – June, 2019	limits and continuity of vector functions, differentiation and integration of vector functions.

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

Name of the Teacher	Duration	Course
Dr. Swapan Mukhopadhyay	July – September, 2018	**CoreV (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, 2018	*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, 2018	**CoreVI (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, 2018	*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, 2018	**Core VII (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, 2018	*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, 2018	**SEC - I (C Programming)** *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, 2018	*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, 2018	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, 2018	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]

Module for Semester – IV (New CBCS Syllabus under Bankura University):

Name of the Teacher	Duration	Course
Dr. Swapan Mukhopadhyay	January – March, 2019	**Core – VIII (Riemann Integration and Series of Functions)** *Unit – I*: Riemann integration: inequalities of upper and lower sums, Darbaux integration, Darbaux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two Definitions. Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals. Fundamental theorem of Integral Calculus. *Unit – II*: Improper integrals. Convergence of Beta and Gamma functions.

		Unit – III: Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test. [12L]
	April – June, 2019	*Unit IV* Fourier series: Definition of Fourier coefficients and series, Reimann Lebesgue lemma, Bessel's inequality, Parseval's identity, Dirichlet's condition. Examples of Fourier expansions and summation results for series. *Unit V* Power series, radius of convergence, Cauchy Hadamard Theorem. Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem. [8L]
Dr. SamiranKarmakar	January – March, 2019	**Core – IX (Multivariate Calculus)** *Unit – I*: Functions of several variables, limit and continuity of functions of two or more variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems *Unit – II*: Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals. [12L]
	April – June, 2019	*Unit III* Definition of vector field, divergence and curl. Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path. *Unit IV* Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem. [8L]
Mr. UtpalBadyakar	January – March, 2019	**Core – X (Ring Theory and Linear Algebra 1)** *Unit I:* Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, ideal generated by a

		subset of a ring, factor rings, operations on ideals, prime and maximal ideals. [12L]
	April – June, 2019	*Unit II:* Ring homomorphisms, properties of ring homomorphisms. Isomorphism theorems I, II and III, field of quotients.
Dr. Mridula Sarkar	January – March, 2019	*Unit III:* Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces [8L]
	April – June, 2018	*Unit IV:* Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.
Mr. UtpalBadyakar	January – March, 2019	**SEC - II (Graph Theory)** *Unit I:* Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi‐partite graphs isomorphism of graphs. *Unit II:* Eulerian circuits, Eulerian graph, semi-Eulerian graph, theorems, Hamiltonian cycles,theorems Representation of a graph by matrix, the adjacency matrix, incidence matrix, weighted graph, [12L]
	April – June, 2019	*Unit II:* Travelling salesman's problem, shortest path, Tree and their properties, spanning tree, Dijkstra's algorithm, Warshall algorithm.

8. Module for Part – III:

Name of the Teacher	Duration	Course
Dr. Swapan Mukherjee	August – October, 2018	**Paper – V (Old Syllabus)** *Metric Space*: Metric, examples of standard metric spaces including Eucleadean and Discrete metrics; open ball, closed ball, open sets; metric topology; closed sets, limit points. and their fundamental properties; interior, closure and boundary of subsets and their interrelation; denseness; separable and second countable metric spaces and their relationship. Continuity: Definition of continuous functions, algebra of real/complex valued continuous functions, distance between a point and a subset, distance between two subsets. Connectedness: Connected subsets of the real line R, open connected subsets in R^2, components; components of open sets in R and R^2; Structure of open set in R, continuity and connectedness; intermediate value theorem. Sequence and completeness: Sequence, subsequence and their convergence; Cauchy sequence and completeness, completeness of R^n; Cantor's theorem concerning completeness. Definition of completion of

		a metric space, construction of the reals as the completion of the incomplete metric space of the rationals with usual distance (proof not required). Continuity preserves convergence. Compactness: Definitions (by means of open covering), Compact metric spaces and finite intersection property (FIP) of closed sets; Compact subsets, continuity and compactness; sequential compactness, Equivalence between compactness and sequential compactness, relation between compactness, completeness and total boundedness. Heine-Borel theorem concerning characterization of compact subsets of R^n. Uniform continuity and continuity on compact sets; distance between two non empty disjoint closed set one of which is compact is a positive real. [50L]
	November – December, 2018	Complex Analysis: Introduction of complex number as ordered pair of reals, geometric interpretation, metric structure of the complex plane **C**, regions in **C.** Stereographic projection and extended complex plane $\mathbf{C}_\propto$ and circles in $\mathbf{C}_\propto$ Continuity and differentiability of a complex function. Analytic functions and Cauchy Riemann equation, harmonic functions. Power series, radius of convergence, sum function and its analytic behaviour within the circle of convergence, Cauchy-Hadamard Theorem. Introduction of exp(z), sin$z$, cos$z$, tan$z$ and the branches of log$z$ and their analytic behaviour. Transformation (mapping), Concept of Conformal mapping, Bilinear (Mobius) transformation and its geometrical meaning, fixed points and circle preserving character of Mobius transformation. [20L]
	January – March, 2019	Real Analysis: Definition of Riemann integration, Uniqueness, Cauchy's criterion, Linear property, Darboux theory of Riemann integration, equivalence, Darboux theorem(proof not required), Riemann integral as the limit of a sum, equivalence. Fundamental theorem of integral calculus, Properties of the Riemann integral; Riemann integrability of continuous and monotone functions, discontinuous function. First and second Mean value theorems of Integral Calculus. Functions defined by integrals, their continuity and differentiability. Convergence of sequence and series of functions, uniform convergence, Cauchy's Criterion of uniform convergence, continuity of sum function of a uniformly convergent series of continuous functions, term by term differentiation and integration for proper integrals. Functions of several variables, theory of extrema, maxima, minima, Lagranges' method of miltipliers, Jacobian, Implicit function theorem (proof not required). Integral as a function of parameter. Differentiation and integration under the sign of integration, change of order of integration for repeated integrals. Inproper integrals, their convergance(for unbounded functions and unbounded range of integration) Abel's and Dirchlets' test, Beta and

		Gamma function, Evaluation of improper integrals: $\int_0^{\frac{\pi}{2}} \log \sin x \, dx$; $\int_0^{\infty} \frac{\sin x}{x} dx$; $\int_0^{\infty} e^{-\alpha x} \frac{\sin \beta x}{x} dx, \alpha > 0$; and integrals dependent on them. Fourier series associated with a function, Series of odd and even functions, Main theorem concerning Fourier series expansion of piece wise monotone functions (proof not required). [50L]
Ms. Mridula Sarkar	August – October, 2018	**<u>Paper – VI</u>** ***Physical Foundations of Classical Dynamics : (Marks - 10)*** Inertial frames, Newton's laws of motion, Galilean transformation. Form-invariance of Newton's laws of motion under Galilean transformation. Fundamental forces in classical physics (gravitation). Electric and Magnetic forces, action-at-a-distance. Body forces; contact forces: Friction, Viscosity. [10L] ***II. Dynamics of a system of particles and of a rigid body (Vector treatment): (Marks - 40)*** ***System of particles :*** Fundamental concepts, centre of mass, momentum, angular momentum, kinetic energy, work done by a field of force, conservative system of forces – potential and potential energy, internal potential energy, total energy. Following important results to be deduced : (i) Centre of mass moves as if the total external force were acting on the entire mass of the system concentrated at the centre of mass (examples of exploding shell, jet and rocket propulsion). (ii) The total angular momentum of the system about a point is the angular momentum of the system concentrated at the centre of mass, plus the angular momentum for motion about the center. (iii) Similar theorem as in (ii) for kinetic energy. Conservation laws: conservation of linear momentum, angular momentum and total energy for conservative system of forces. An idea of constraints that may limit the motion of the system, definition of rigid bodies. D'Alembert's principle, principle of virtual work for equilibrium of a connected system. [30L]
	November – December, 2018	***Dynamics of Rigid Body :*** Moments and products of inertia (in three-dimensional rectangular co-ordinates). Inertia matrix. Principal values and principal axes of inertia matrix. Principal moments and principal axes of inertia for (i) a rod, (ii) a rectangular plate, (iii) a circular plate, (iv) an elliptic plate, (v) a sphere, (vi) a right circular cone, (vii) a rectangular parallelepiped and (viii) a circular cylinder. [12L]
	January – March, 2019	Two-dimensional motion of a rigid body. Following examples of the two-dimensional motion of a rigid body to be studied :

		(i) Motion of a uniform heavy sphere (solid and hollow) along a perfectly rough inclined plane; (ii) Motion of a uniform heavy circular cylinder (solid and hollow) along a perfectly rough inclined plane: (iii) Motion of a rod when released from a vertical position with one end resting upon a perfectly rough table or smooth table. (iv) Motion of a uniform heavy solid sphere along an imperfectly rough inclined plane; (v) Motion of a uniform circular disc, projected with its plane vertical along an imperfectly rough horizontal plane with a velocity of translation and angular velocity about the centre. [13L]
Ms. Mridula Sarkar	August – October, 2018	***III) Analytical Statics:*** Forces, concurrent forces, Parallel forces. Moment of a force, Couple. Resultant of a force and a couple (Fundamental concept only). Reduction of forces in three-dimensions, Pointsot's central axis, conditions of equilibrium. Virtual work, Principle of Virtual work. Simple examples of finding tension or thrust in a two-dimensional structure in equilibrium by the principle of virtual work. Stable and unstable equilibrium- Energy test of stability, stability of a heavy body resting on a fixed body with smooth surfaces- simple examples. General equations of equilibrium of a uniform heavy inextensible string under the action of given coplanar forces, common catenary, catenary of uniform strength. [20L]
	November – December, 2018	***Elements of Continuum Mechanics with Hydrostatics (Marks - 30)*** ***1. Elements of Continuum Mechanics:*** Deformable body. Idea of a continuum (continuous medium). Surface forces or contact forces. Stress at point in a continuous medium, stress vector, components of stress (normal stress and shear stress) in rectangular Cartesian co-ordinate system; stress matrix. Definition of ideal fluid and viscous fluid. [10L]
	January – March, 2019	II. ***Hydrostatics:*** Pressure (pressure at a point in a fluid in equilibrium is same in every direction). Incompressible and compressible fluid, Homogeneous and non-homogeneous fluids. Equilibrium of fluids in a given field of force; pressure gradient. Equi-pressure surfaces, equilibrium of a mass of liquid rotating uniformly like a rigid body about an axis. Simple applications. Pressure in a heavy homogeneous liquid. Trust on plane surfaces: center of pressure, effect of increasing the depth without rotation. Centre of pressure of a triangular & rectangular area and of a circular area immersed in any manner in a heavy homogeneous liquid. Simple problems. Thrust on curved surfaces:Archimedes'' principle. Equilibrium of freely floating bodies under constraints. (Consideration of stability not required). Equation of state of a 'perfect gas', Isothermal and adiabatic processes

		in an isothermal atmosphere. Pressure and temperature in atmosphere in convective equilibrium. [20L]
Dr. SamiranKarmakar	August – October, 2018	**Paper – VII** ***Mathematical Probability:*** Concept of mathematical probability, classical statistical and axiomatic definition of probability, addition and multiplication rule of probability. Conditional probability, Baye's theorem. Independent events. Bernoulli's trial, Binomial and Multinomial Law. Random Variables. Distribution function. Discrete and continuous distributions. Binomial, Poisson, Uniform, Normal, Cauchy, Gamma, distribution and Beta distribution of the first and second kind. Transformation of random variables. [15L]
	November – December, 2018	Discrete and continuous distributions in two dimensions. Mathematical expectation. Theorems on the expectation of sum and product of random variables. [10L]
	January – March, 2019	Two-dimensional expectation, covariance, Correlation co-efficient. Moment generating function. Characteristic function, conditional expectations, Regression curve, $\chi^2$and t distributions and their interrelations, convergence in probability Chebyshev's inequality. Bernoulli's limit theorem, Convergence inprobability. Concept of asymptotically normal distribution, central limit theorem in case of equal components. [15L]
Dr. SamiranKarmakar	August – October, 2018	***Elements of Operations Research (Marks - 40)*** General introduction to optimization problem, Definition of L.P.P., Mathematical formulation of the problem, Canonical & Standard form of L.P.P., Basic solutions, feasible, basic feasible & optimal solutions, Reduction of a feasible solution to basic feasible solution. Hyperplanes and Hyperspheres, Convex sets and their properties, Convex functions, Extreme points, Convex feasible region, Convex polyhedron, Polytope. Graphical solution. of L. P.P. Fundamental theorems of L.P.P., Replacement of a basis vector, Improved basic feasible solutions, Unbounded solution, Condition of optimality, Simplex method, Simplex algorithm, Artificial variable technique (Big M method, Two phase method), Inversion of a matrix by Simplex method. Duality in L.P.P.: Concept of duality, Fundamental properties of duality, Fundamental theorem of duality, Duality & Simplex method, Dual simplex method and algorithm. [25L]
	November – December, 2018	Transportation Problem (T.P.) : Matrix form of T.P., the transportation table, Initial basic feasible solutions (different methods like North West corner, Row minima, Column minima, Matrix minima & Vogel's Approximation method), Loops in T.P. table and their properties, Optimal solutions, Degeneracy in T.P., Unbalanced T.P. Theory of Games: Introduction, Two-person zero-sum games, Minimax

		and Maximin principles, Minimax and Saddle point theorems, Mixed Strategies games without saddle points, Minimax (Maximin) criterion, The rules of Dominance. Solution methods of games without Saddle point: Algebraic method, Matrix method, Graphical method and Linear Programming method. [15L]
	January – March, 2019	***Statistics (Marks - 20)*** Description of statistical data, simple measures of central tendency-mean, mode, median, measures of dispersion – standard deviation, quartile deviation. Moments and measures of Skewness and Kurtosis. Bivariate frequency distribution. Scatter diagram, Correlation co-efficients, regression lines and their properties. Concept of statistical population and random sample. Sampling distribution of sample mean and related χ^2, t and F distribution. Estimation – Unbiasedness and minimum variance, consistency and efficiency, method of maximum likelihood, interval estimation for mean or variance of normal populations. [20L]
Dr. UtpalBadyakar	August – October, 2018	***Numerical Analysis (Marks - 35)*** Approximation of numbers, decimal places, significant figures. Round off. errors in numerical calculations. Addition, subtraction, multiplication and division. Loss of significant figures, Inherent errors in numerical methods. Ordinary and divided differences, Propagation of error in difference table. Problems of interpolation, remainder in interpolation. Newton's forward and backward interpolation formulae. Newton's divided difference formula. Central interpolation formulae: Gauss, Stirling and Bessel's formulae (Deduction not necessary). Lagrange's interpolation formula. Inverse interpolation formula. Numerical integration: Newton-Cotes' formula (error term may be stated). Trapezoidal rule, Simpson's one-third rule, Inherent errors, degree of precision. [25L]
	November – December, 2018	Numerical methods for finding the real roots of algebraic and transcendental equations: Location of roots by Tabulation and Graphical method. Finding the roots by the method of (i) Regula-Falsi (ii) Fixed point iteration and (iii) Newton Raphson & their convergences. Solution of a system of linear equation: Gauss' elimination method and Gauss-Seidel method; statement of convergence criteria. Solution of first order ordinary differential equations: Picard's method, Euler's method (modified), Taylor's method and Runge-Kutta's method of second and fourth order (derivation of 2ndorder formula only). [15L]
	January – March, 2019	***Computer Programming (Marks – 15)*** Anatomy of a computer: Basic structure, Input unit, Output unit, Memory unit, Control unit, Arithmetic logical unit. Computer generation and classification; Machine language, Assembly language, computer-high level languages. Compiler, Interpreter, Operating system. Source programs and objects programs. Binary number system,

		Conversions and arithmetic operation. Representation for Integers and Real numbers, Fixed and floating point. Programming in FORTRAN-77 Language: Fortran Characters. Basic data types; Numeric Constant & Variables; Arithmetic Expressions, Assignment statements, I/O –statements (Format-free); STOP & END statement; Control statement: Unconditional GOTO, Computed GOTO, Assigned GOTO, Logical IF and Arithmetic IF. Repetitive operations: DO statement; CONTINUE statement, Arithmetic statement functions; Library functions in FORTRAN. [20L]

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

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

III) Group A: Dr. SamiranKarmakar
IV) Group B: Dr. Mridula Sarkar

November – December, 2018	Prerequisites: PC – operating system and DOS commands, Concepts of Algorithms, Flowchart and Subscripted variables 1. Finding a real Root of an equation by (a) Fixed point iteration and (b) Newton-Rapson's method. [20L]
January – March, 2019	9. 2. Finding the solution of linear equations by Gauss-Seidel method 10. **3.** Interpolation (Taking at least six points) by Lagrange's formula 11. 4. Integration by a. (i) Trapezoidal rule b. (ii) Simpson's 1/3rd rule (taking at least 10 sub-intervals) 12. 5. Solution of a 1storder ordinary differential equation by fourth-order R. K. Method, taking at least four steps. [30L]