

SEMESTER SYSTEM COURSE STRUCTURE

FOR

M. SC. COURSE IN MATHEMATICS (PURE AND APPLIED STREAMS)

Under Choice Based Credit System (CBCS)

Effective from the session 2021-23



**DEPARTMENT OF MATHEMATICS
DIRECTORATE OF OPEN AND DISTANCE LEARNING
UNIVERSITY OF KALYANI
NADIA, WEST BENGAL**

M.SC. IN MATHEMATICS
(PURE AND APPLIED STREAMS)
TOTAL CREDITS: 100, FULL MARKS: 1650

COMMON ABBREVIATIONS

COR: Core Course; **AECC:** Ability Enhancement Compulsory Course;
GEC: Generic Elective Course; **SEC:** Skill Enhancement Course; **DSE:** Discipline Specific Elective
SEE: Semester End Examination; **IA:** Internal Assessment

COURSE OUTLINE

SEMESTER I

TOTAL CREDITS: 26; DURATION: 6 Months;
LEARNER STUDY HOURS: $180 \times 4 + 60 = 780$ Hours
(Counselling + Self Study + Assignments = 78 + 657 + 45)

Course	Stream	Topics	SEE (80)	IA (20)	TOTAL	COUNSELLING HOURS	CREDITS
COR 1.1	COMMON TO BOTH STREAMS	<ul style="list-style-type: none"> • Real Analysis I • Complex Analysis I • Functional Analysis I 	<ul style="list-style-type: none"> • 25 • 30 • 25 	<ul style="list-style-type: none"> • 7 • 6 • 7 	100	18	6
COR 1.2		<ul style="list-style-type: none"> • Ordinary Differential Equations • Partial Differential Equations 	<ul style="list-style-type: none"> • 40 • 40 	<ul style="list-style-type: none"> • 10 • 10 	100	18	6
COR 1.3		<ul style="list-style-type: none"> • Potential Theory • Abstract Algebra I • Operations Research I 	<ul style="list-style-type: none"> • 30 • 25 • 25 	<ul style="list-style-type: none"> • 6 • 7 • 7 	100	18	6
DSE 1.4	APPLIED	<ul style="list-style-type: none"> • Mechanics of Solids • Non-linear Dynamics 	<ul style="list-style-type: none"> • 40 • 40 	<ul style="list-style-type: none"> • 10 • 10 	100	18	6
	PURE	<ul style="list-style-type: none"> • Differential Geometry I • Topology I 	<ul style="list-style-type: none"> • 40 • 40 	<ul style="list-style-type: none"> • 10 • 10 	100	18	
AECC 1.5	COMMON	Computer Programming in C (Theory)	40	10	50	6	2
Total			360	90	450	78	26

Semester I

COR 1.1

Marks: 100; Credits: 6

Unit	Topic	Counselling Duration
Block I: Real Analysis I; Marks 32 (SEE: 25; IA: 07)		
1	Cardinal number : Definition, Schröder-Bernstein theorem, Order relation of cardinal numbers, Arithmetic of cardinal numbers, Continuum hypothesis	54 Mins
2	Cantor's set : Construction and its presentation as an uncountable set of measure zero	54 Mins
3	Functions of bounded variation : Definition and basic properties, Lipschitz condition, Jordan decomposition,	54 Mins
4	Nature of points of discontinuity, Nature of points of non-differentiability, Convergence in variation (Helly's First theorem)	54 Mins
5	Absolutely continuous functions : Definition and basic properties, Deduction of the class of all absolutely continuous functions as a proper subclass of all functions of bounded variation,	54 Mins
6	Characterization of an absolutely continuous function in terms of its derivative vanishing almost everywhere	54 Mins
7	Riemann-Stieltjes integral : Existence and basic properties, Integration by parts, Integration of a continuous function with respect to a step function,	54 Mins
8	Convergence theorems in respect of integrand, convergence theorem in respect of integrator (Helly's Second theorem)	54 Mins
9	Gauge partition : Definition of a delta-fine tagged partition and its existence, Lebesgue's criterion for Riemann integrability,	54 Mins
10	Delta-fine free tagged partition and an equivalent definition of the Riemann integral	54 Mins
Block II: Complex Analysis I; Marks 36 (SEE: 30; IA: 06)		
11	Riemann's sphere, point at infinity and the extended complex plane	54 Mins
12	Functions of a complex variable, limit and continuity. Analytic functions, Cauchy-Riemann equations	54 Mins
13	Complex integration. Cauchy's fundamental theorem (statement only) and its consequences. Cauchy's integral formula. Derivative of an analytic function	54 Mins

14	Morera's theorem, Cauchy's inequality, Liouville's theorem, Fundamental theorem of classical algebra	54 Mins
15	Uniformly convergent series of analytic functions. Power series. Taylor's theorem. Laurent's theorem	54 Mins
Block III: Functional Analysis I; Marks 32 (SEE: 25; IA: 07)		
16	Metric spaces. Brief discussions of continuity, completeness, compactness. Hölder's and Minkowski's inequalities (statement only)	54 Mins
17	Baire's (category) theorem. The spaces and. Banach's fixed point theorem	54 Mins
18	Applications to solutions of certain systems of linear algebraic equations, Fredholm's integral equation of the second kind, implicit function theorem. Kannan's fixed point theorem	54 Mins
19	Real and Complex linear spaces. Normed induced metric. Banach spaces, Riesz's lemma	54 Mins
20	Finite dimensional normed linear spaces and subspaces, completeness, compactness criterion, equivalent norms	54 Mins
Total		18 Hours

References:**Block I:**

1. P. Natanson: Theory of Integrals of a Real Variable (Vol. I and II).
2. B. K. Lahiri and K. C. Ray: Real Analysis.
3. W. Rudin: Principles of Mathematical Analysis.
4. A. G. Das: The Generalized Riemann Integral.
5. G. Das: Theory of Integration – The Riemann, Lebesgue and Henstock-Kurzweil Integrals.
6. W. Sierpinsky: Cardinal Number and Ordinal Number.
7. H. L. Royden: Real Analysis

Block II:

1. A. I. Markushevich: Theory of Functions of a Complex Variable (Vol. I, II and III).
2. R. V. Churchill and J. W. Brown: Complex Variables and Applications.
3. E. C. Titchmarsh: The Theory of Functions.
4. E. T. Copson: An Introduction to the Theory of Functions of a Complex Variable.
5. J. B. Conway: Functions of One Complex Variable.
6. L. V. Ahlfors: Complex Analysis.
7. H. S. Kasana: Complex Variables – Theory and Applications.
8. S. Narayan and P. K. Mittal: Theory of Functions of a Complex Variable.
9. A. K. Mukhopadhyay: Functions of Complex Variables and Conformal Transformation.
10. J. M. Howi: Complex Analysis.
11. S. Ponnusamy: Foundation of Complex Analysis.

12. H. A Priestly: Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
 13. E. M. Stein and R. Shakrachi: Complex Analysis, Princeton University Press.

Block III:

1. E. Kreyszig: Introductory Functional Analysis with Applications.
2. W. Rudin: Functional Analysis.
3. N. Dunford and L. Schwart : Linear Operators (Part I).
4. A. E. Taylor: Introduction to Functional Analysis.
5. B. V. Limaye: Functional Analysis.
6. K. Yoshida: Functional Analysis.
7. B. K. Lahiri: Elements of Functional Analysis.

COR 1.2**Marks: 100; Credits: 6**

Unit	Topic	Counselling Duration
Block I: Ordinary Differential Equations; Marks 50 (SEE: 40; IA: 10)		
1	Existence of solutions: Picard's Existence theorem for equation $dy / dx = f(x,y)$, Gronwall's lemma, Picard-Lindelöf method of successive approximations.	54 Mins
2	Solutions of linear differential equations of nth order. Wronskian, Abel's identity.	54 Mins
3	Linear dependence and independence of the solution set, Fundamental set of solutions.	54 Mins
4	Green's function for boundary value problem and solution of non-homogenous linear equations.	54 Mins
5	Adjoint and self-adjoint equations. Lagrange's identity.	54 Mins
6	Sturm's separation and comparison theorems for second order linear equations. Regular Sturm-Liouville problems for second order linear equations.	54 Mins
7	Eigen values and eigen functions, expansion in eigen functions.	54 Mins
8	Solution of linear ordinary differential equations of second order in complex domain.	54 Mins
9	Existence of solutions near an ordinary point and a regular singular point.	54 Mins
10	Solutions of Hyper geometric equation and Hermite equation, Introduction to special functions.	54 Mins
Block II: Partial Differential Equations; Marks 50 (SEE: 40; IA: 10)		
11	Introduction and pre-requisite, Genesis and types of solutions of Partial Differential Equations.	54 Mins

12	First order Partial Differential Equations, Classifications of First Order Partial Differential Equations. Charpit's Method for the solution of First Order non-linear Partial Differential Equation.	54 Mins
13	Linear Partial Differential Equations of second and higher order, Linear Partial Differential Equation with constant coefficient, Solution of homogeneous irreducible Partial Differential Equations	54 Mins
14	Method of separation of variables, Particular integral for irreducible non-homogeneous equations	54 Mins
15	Linear partial Differential equation with variable coefficients, Canonical forms, Classification of second order partial differential equations, Canonical transformation of linear second order partial differential equations	54 Mins
16	Parabolic equation, Initial and boundary conditions, Heat equation under Dirichlet's Condition, Solution of Heat equation under Dirichlet's Condition ,	54 Mins
17	Solution of Heat equation under Neuman Condition, Solution of Parabolic equation under non-homogeneous boundary condition	54 Mins
18	Hyperbolic equation, occurrence of wave equations, in Mathematical Physics, Initial and boundary conditions, Initial value problem	54 Mins
19	D' Alembert's solutions, vibration of a string of finite length, Initial value problem for a non-homogeneous wave equation	54 Mins
20	Elliptic equations, Gauss Divergence Theorem, Green's identities, Harmonic functions, Laplace equation in cylindrical and spherical polar coordinates, Dirichlet's Problem, Neumann Problem	54 Mins
Total		18 Hours

References:**Block I:**

1. G. F. Simmons: Differential Equations.
2. E. E. Coddington and N. Levinson: Theory of Ordinary Differential Equations.
3. M. Birkhoff and G. C. Rota: Ordinary Differential Equations.
4. M.D. Raisinghania: Advanced Differential Equations.
5. E. L. Ince: Ordinary Differential Equations

Block II:

1. A. K. Nandakumaran and P. S. Datti: Partial Differential equations, Cambridge University Press, 2020.
2. L. C. Evans: Partial Differential equations, Vol 19, AMS.
3. G. Evans: Analytic methods for partial differential equations, Springer, 2001.
4. Phoolan Prasad and Renuka Ravindran: Partial differential Equations, New Age Int., 2011.
5. T. Amaranath: An elementary course in partial differential equations, Narosa, 2014.
6. K. Sankara, Rao: Introduction to partial differential equations, PHI, 2015.

7. I. N. Sneddon: Elements of partial differential equations, Mc Grew Hill, New York, 1957.
8. Robert C. McOwen: Partial differential equations, Pentice hall, 2013.

COR 1.3

Marks: 100; Credits: 6

Unit	Topic	Counselling Duration
Block I: Potential Theory; Marks 36 (SEE: 30; IA: 06)		
1	Concept of potential and attraction for line, surface and volume distributions of matter.	54 Mins
2	Laplace's equation, problems of attraction and potential for simple distribution of matter	54 Mins
3	Existence and continuity of first and second derivatives of potential within matter. Poisson's equation, work done by mutual attraction, problems	54 Mins
4	Integral theorem of potential theory (statement only) Green's identities, Gauss' average value theorem,	54 Mins
5	Continuity of potential and discontinuity of normal derivative of potential for a surface distribution, potential for a single and double layer, Discontinuity of potential	54 Mins
6	Boundary value problems of potential theory. Green's function, solution of Dirichlet's problem for a half-space	54 Mins
7	Solid and surface spherical harmonics	54 Mins
Block II: Abstract Algebra I; Marks 32 (SEE: 25; IA: 07)		
8	Preliminaries: Review of earlier related concepts-Groups and their simple properties	54 Mins
9	Class equations on groups and related theories: Conjugacy class equations, Cauchy's theorem,	54 Mins
10	p-Groups, Sylow theorems and their applications, simple groups	54 Mins
11	Direct Product on groups: Definitions, discussion on detailed theories with applications	54 Mins
12	Solvable groups: Related definitions and characterization theorems, examples	54 Mins
13	Group action: Definition and relevant theories with applications	54 Mins
Block III: Operations Research-I; Marks 32 (SEE: 25; IA: 07)		

14	Extension of Linear Programming Methods : Theory of Revised Simplex Method and algorithmic solution approaches to linear programs	54 Mins
15	Dual-Simplex Method, Decomposition principle and its use to linear programs for decentralized planning problems	54 Mins
16	Integer Programming (IP) : The concept of cutting plane for linear integer programs, Gomory's cutting plane method	54 Mins
17	Gomory's All-Integer Programming Method, Branch-and-Bound Algorithm for general integer programs	54 Mins
18	Sequencing Models : The mathematical aspects of Job sequencing and processing problems, Processing n jobs through Two machines, processing n jobs through m machines	54 Mins
19	Nonlinear Programming (NLP) : Convex analysis, Necessary and Sufficient optimality conditions, Cauchy's Steepest descent method,	54 Mins
20	Karush-Kuhn-Tucker (KKT) theory of NLP, Wolfe's and Beale's approaches to Quadratic Programs	54 Mins
Total		18 Hours

References:**Block I:**

1. O. D. Kellog: Theory of Potential.
2. P. K. Ghosh: Theory of Potential.
3. A. S Ramsey: Newtonian Attraction.
4. T. M. MacRobert: Spherical Harmonics.

Block II:

1. M.K. Sen, S. Ghosh and P. Mukhopadhyay: Abstract Algebra, University Press.
2. Luthar & Passi: Algebra (Vol. 1).
3. John B. Fraleigh: A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
4. D. S. Dummit, R. M. Foote: Abstract Algebra, 2nd edition, Wiley Student edition.
5. J. A. Gallian: Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, 1999.
6. I. N. Herstein, Topics in Algebra: Wiley Eastern Ltd. New Delhi, 1975.
7. T. W. Hungerford: Algebra, Springer, 1980.
8. Joseph J. Rotman: An introduction to the theory of groups, Springer-Verlag, 1990.
9. M. Artin: Abstract Algebra, 2nd Ed., Pearson, 2011.
10. Malik, Mordeson and Sen: Fundamentals of Abstract Algebra, McGraw-Hill, 1997.
11. S. Lang: Algebra (2nd ed.), Addition-Wesley.
12. M. R. Adhikari and Abhishek Adhikari: Groups, Rings and Modules with Applications.
13. N. Jacobson: Lecturers in Abstract Algebra.

Block III:

1. Linear Programming – G. Hadley.
2. Mathematical Programming Techniques – N. S.Kambo.

3. Nonlinear and Dynamic Programming – G. Hadley.
4. Operations Research – K. Swarup, P. K. Gupta and Man Mohan.
5. Operations Research – H. A. Taha.
6. Operations Research – S. D. Sharma.
7. Introduction to Operations Research – A. Frederick, F. S. Hillier and G. J. Lieberman.
8. Optimization: Theory and Applications – S. S. Rao.
9. Nonlinear and Mixed-Integer Optimization – Christodoulos A. Floudas.

DSE 1.4 (Applied Stream)

Marks: 100; Credits: 6

Unit	Topic	Counselling Duration
Block I: Mechanics of Solids; Marks 50 (SEE: 40; IA: 10)		
1	Brief discussion of tensor transformation, symmetric tensor, alternating tensor. Analysis of strain, Normal strain, shearing strain and their geometrical interpretations	54 Mins
2	Strain quadratic of Cauchy, Principal strains, Invariants, Saint-Venant's equations of compatibility, equivalence of Eulerian and Lagrangian components of strain in infinitesimal deformation	54 Mins
3	Analysis of stress, stress tensor, Equations of equilibrium and motion. Stress quadric of Cauchy. Principal stress and invariants, strain energy function	54 Mins
4	Graphical representation of elastic deformation. Equations of elasticity. Generalized Hooke's law. Homogeneous isotropic media. Elastic moduli for isotropic media.	54 Mins
5	Equilibrium and dynamical equations for an isotropic elastic solid. Connections of the strain energy function with Hooke's Law, uniqueness of solutions. Clapeyron's Theorem, Beltrami-Michell compatibility equations, Saint-Venant's principle.	54 Mins
6	Equilibrium of isotropic elastic solid: Deformations under uniform pressure. Deformations of prismatical bar stretched by its own weight and a cylinder immersed in a fluid, twisting of circular bar by couples at the ends	54 Mins
7	Torsion : Torsion of cylindrical bars, Torsional rigidity, Torsion function, Lines of shearing stress, simple problems related to circle, ellipse and equilateral triangle	54 Mins
8	Two-dimensional problems: Plane strain, Plane stress, Generalised plane stress, Airy's stress function, General solution of biharmonic equation.	54 Mins
9	Stresses and displacements in terms of complex potentials. Simple problems, stress function appropriate to problems of plane stress	54 Mins
10	Waves: Propagation of waves in an isotropic elastic medium, waves of dilatation and distortion. Plane waves	54 Mins

Block II: Non-Linear Dynamics; Marks 50 (SEE: 40; IA: 10)		
11	Linear autonomous systems: Linear autonomous systems, existence, uniqueness and continuity of solutions, diagonalization of linear systems,	54 Mins
12	Fundamental theorem of linear systems, the phase paths of linear autonomous plane systems	54 Mins
13	Complex eigen values, multiple eigen values, similarity of matrices and Jordon canonical form, stability theorem	54 Mins
14	Reduction of higher order ODE systems to first order ODE systems, linear systems with periodic coefficients	54 Mins
15	Linearization of dynamical systems: Two, three and higher dimension.	54 Mins
16	Population growth. Lotka-Volterra system	54 Mins
17	Stability: Asymptotic stability (Hartman's theorem), Global stability (Liapunov's second method)	54 Mins
18	Limit set, attractors, periodic orbits, limit cycles	54 Mins
19	Bendixon criterion, Dulac criterion, Poincare-Bendixon Theorem.	54 Mins
20	Stability and bifurcation: Saddle-Node, transcritical and pitchfork bifurcations. Hopf- bifurcation	54 Mins
Total		18 Hours

References:**Block I:**

1. S. Sokolnikoff: Mathematical Theory of Elasticity.
2. A. E. H. Love: A Treatise on the Mathematical Theory of Elasticity.
3. Y. C. Fung: Foundations of Solid Mechanics.
4. R.N. Chatterjee: Mathematical Theory of Continuum Mechanics. 7. H. L. Royden: Real Analysis

Block II:

1. D. W. Jordan and P. Smith (1998): Nonlinear Ordinary Equations- An Introduction to Dynamical Systems (Third Edition), Oxford Univ. Press.
2. L. Perko (1991): Differential Equations and Dynamical Systems, Springer Verlag.
3. F. Verhulst (1996): Nonlinear Differential Equations and Dynamical Systems, Springer Verlag.
5. H. I. Freedman - Deterministic Mathematical Models in Population Ecology.
6. Mark Kot (2001): Elements of Mathematical Ecology, Cambridge Univ. Press.
7. W. G. Kelley and A. C. Peterson, Difference Equations- An Introduction with Applications, Academic Press.
8. S. Elaydi. An Introduction of Difference Equation, Springer.

DSE 1.4 (Pure Stream)**Marks: 100; Credits: 6**

Unit	Topic	Counselling Duration
Block I: Differential Geometry I; Marks 50 (SEE: 40; IA: 10)		
1	Vector valued functions, Directional Derivatives, Total derivatives,	54 Mins
2	Statement of Inverse and Implicit Function Theorems, Curvilinear coordinate system in E3.	54 Mins
3	Reciprocal base system. Riemannian space. Reciprocal metric tensor, Christoffel symbols, Covariant differentiation of vectors and tensors of rank 1 and 2.	54 Mins
4	Riemannian curvature tensor, Rieci tensor and scalar curvature. Space of constant curvature, Einstein space	54 Mins
5	On the meaning of covariant derivative. Intrinsic differentiation. Parallel vector field.	54 Mins
6	Tensor Algebra on finite dimensional vector spaces, Inner product spaces, matrix representation of an inner product ,	54 Mins
7	Linear functional, r-forms, Exterior product, Exterior derivative	54 Mins
8	Regular curves, curvature, torsion, curves in plane, signed curvature, curves in spaces,	54 Mins
9	Serret Frenet formulae, Isoperimetric inequality, four vertex theorem	54 Mins
10	Introduction to surface, Definition example, first fundamental form of surfaces	54 Mins
Block II: Topology I; Marks 50 (SEE: 40; IA: 10)		
11	Definition and examples of topological spaces.	54 Mins
12	Basis for a given topology, necessary and sufficient condition for two bases to be equivalent,	54 Mins
13	Sub-base, topologizing of two sets from a sub base	54 Mins
14	Closed sets, closure and interior, their basic properties and their relations	54 Mins
15	Neighbourhoods, exterior and boundary, dense sets. Accumulation points and derived sets. Subspace topology	54 Mins
16	Continuous, open, closed mappings, examples and counter examples,	54 Mins
17	Their different characterizations and basic properties	54 Mins
18	Pasting lemma, homeomorphism, topological properties.	54 Mins
19	The countability axioms, Separation axioms	54 Mins
Total		18 Hours

References:**Block I:**

1. Munkres: Analysis on manifolds,
2. Andrew Pressley: Elementary Differential Geometry.
3. M. P. DoCarmo: Differential Geometry of curves and surfaces.
4. Christian Bar: Differential geometry.
5. Nirmala Prakash: Differential geometry
6. I. S. Sokolnikoff: Tensor Analysis, Theory and applications.
7. L. P. Eisenhart: Introduction to Differential Geometry.

Block II:

1. M. A. Armstrong, Basic Topology, Springer (India), 2004,
2. J.R. Munkres, Topology, 2nd Ed., PHI (India), 2002,
3. J. M. Lee: Introduction to topological Manifolds,
4. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw- Hill, New York, 1963.
12. H. A Priestly: Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
13. E. M. Stein and R. Shakrachi: Complex Analysis, Princeton University Press.

AECC 1.5**Marks: 50; Credits: 2**

Unit	Topic	Counselling Duration
Computer Programming in C (Theory); Marks 50 (SEE: 40; IA: 10)		
1	Fundamentals of 'C' Language : Basic structure of a 'C' program, Basic Data type, Constants and Variables, Identifier, Keywords, Constants, Basic data type, Variables, Declaration and Initialization, Statements and Symbolic constants. Compilation and Execution of a 'C' program.	1 Hour
2	Operators and Expressions : Arithmetic, Relational, Logical operators. Increment, Decrement, Control, Assignment, Bitwise, and Special operators. Precedence rules of operators, Type Conversion (casting), Modes of arithmetic expressions, Conditional expressions.	1 Hour
3	Input / Output Operations : Formatted I/O - Single character I/O (getchar(), putchar()), Data I/O (scanf(), printf()), String I/O (gets(), puts()). Programming problems. Decision Making Statements : Branching – if Statement, if-else Statement, Nested if-else Statement. else-if and switch Statements. Loop Control: for Statement, while Statement, do while Statement. break, continue and exit Statements. Programming problems.	1 Hour
4	Functions : Function declaration, Library functions, User defined function, Passing argument to a function, Recursion. Programming problems. Arrays : Array declaration and static memory allocation.	1 Hour

	One dimensional, two dimensional and multidimensional arrays. Passing arrays to functions. Sparse matrix.	
5	Pointers : Basic concepts of pointer, Functions and Pointers. Pointers and Arrays, Memory allocation, Passing arrays to functions, Pointer type casting. Programming problems. Structures and Unions : Declaring a Structure, Accessing a structure element, Storing methods of structure elements, Array of structures, Nested structure, Self – referential structure, Dynamic memory allocation, Passing arrays to function. Union and rules of Union. Programming problems.	1 Hour
6	File Operations: File Input / Output operations – Opening and Closing a file, Reading and Writing a file. Character counting, Tab space counting, File-Copy program, Text and Binary files.	1 Hour
Total		6 Hours

References:

1. Programming in ANSI C: E. Balaguruswamy.
2. Let Us C: Y. Kanetkar.
3. Programming in C Language: B. S. Gottfred.
4. Mastering Algorithm in C: K. Loudon.
5. The C Programming Language: B.W. Kernighan and D. Ritchie.