Barrackpore Rastraguru Surendranath College

Teaching Plan

Department of Mathematics

2022-23

p

NAME OF THE PROGRAMME

M.SC. INMATHEMATICS

PROGRAMME OUTCOME

Successful completion of the two-year M.Sc. course in Mathematics will enable the students to

1. Approach and analyse the problems arising in their chosen careers in a logical manner and apply these skills to any real-life situation.

2. Apply computational and modelling skills to specific tasks, especially in the emerging and developing processes and industries.

3. Independently pursue research work in any area of Pure or Applied Mathematics; work in a group confidently and contribute significantly to any research project

4. Acquire a systematic knowledge of fundamental aspects of various branches of Mathematics which would help them in qualifying National and State-level examinations.

5. Think and analyse independently, and apply their skills in mathematical logic to any profession oftheir choice.

6. Take up pedagogy in Mathematics or related subjects if they are so inclined.

Notes:
You can merge cells in between and add students' seminars and class tests / internal assessment.
For incorporating PO / CO at UG level, you may refer to your WBSU CBCS syllabus.
If not there you can refer to the UGC model syllabus
https://www.ugc.ac.in/ugc_notices.aspx?id=MTA3Nw==

Semester		I	
Course Title	**Algebra**		
Course Code	**MTMP COR 01T**	**Credit**	**4**
Course Outcome	On completion of this course, the students will be able to identify, analyze, classify, demonstrate and explain the acquired knowledge mainly on the following : i) Sylow's theorems and its applications, ii) Jordan Holder Theorem, Solvable groups iii) Prime, primary and maximal ideals iv) Jacobsons radical, semisimple ring, Hilbert Basis Theorem,Unique Factorization Domain, v) Basics of Field extension & Galois theory. Also there is a scope, for applying the acquired knowledge of the above methods/ tools of Algebra, to solve complex mathematical problems in all of its relevant fields of applications, to develop abstract mathematical thinking as well as in discovering new avenues, that facilitates for higher research and its extensions. It also helps to crack lectureship and fellowship exams approved by UGC & CSIR, GATE and SET.		

Scheme of Instruction					
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				

Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping		
Units	**Course Content**	**Lecture Hour (Cumulative)**
I (July-August)	Cayley's theorem. Conjugacy classes and class equation, p-groups. Converse of Lagrange's theorem for finite abelian groups. Sylow's theorems and its applications. Direct product, finitely generated abelian groups. Solvable groups –solvability of S_n, Jőrdan-Holder Theorem.	24
II (August-Sep.)	Ideals, Principal Ideal Domain (PID). Quotient ring, isomorphism and correspondence theorems. Prime, primary and maximal ideals – examples, characterizations and their interrelations. Prime and irreducible elements. Unique Factorization Domain (UFD).	24
III (September-Oct.)	Ring with chain conditions – Noetherian rings and Artinian rings. Polynomial ring, Semi Simple Ring, Jacobson's radical, Hilbert basis theorem.	16

IV (Oct.-Nov.)	Field extension – algebraic and transcendental extension. Splitting field, algebraic closure and algebraically closed field . Separable and normal extension. Galois field.	16
V (Nov.-Dec.)	Galois theory (If time permits) – introduction, basic ideas and results focusing the fundamental theorem of Galois theory. Solvability by radicals.	16

Semester		**I**	
Course Title	**Linear Algebra**		
Course Code	**MTMP COR 02T**	**Credit**	**4**
Course Outcome	On completion of this course, the students will be able to identify, analyze, classify, demonstrate and explain the acquired knowledge on the following : i) Modules with chain conditions(Noetherian and Artinian), Dual Modules, Free Modules, ii) Dual Spaces, Dual Basis, Dimension of Quotient space, iii) Minimal Polynomial, Diagonalization of Matrices, Reduction to Triangular Forms, iv) Jordan Canonical Forms, Rational Canonical Forms, Smith Normal Form, v) Bilinear Forms , Quadratic Forms, Hermitian Forms, vi) Direct sum decomposition theorem, Pricipal Minor Criteron, vii) Sylvester Law Of Inertia, Simultaneous Reduction of Pair of Forms.		

Scheme of Instruction

Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				

Scheme of Examination

Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	Course Content	Lecture Hour (Cumulative)
I(July)	Modules, Basic Concepts, Submodules, Quotient Modules,Isomorphisim Theorems, Correspondence Theorem, Exact Sequence, four lemma and five lemma, Simple Modules, Free modules, Modules with chain conditions(Noetherian and Artinian), Dual Modules, Fundamental Structure Theorem for Fintely Generated Modules over PID- Statement only.	16
II(August)	Matrices and Linear Transformations, Representation of Linear Transformations between finite dimensional vector spaces by Matrices and vice versa, Linear Functionals, Dual Spaces, Dual Basis, Dimension of Quotient space.	16
III (Sep.-Oct.)	Minimal Polynomial, Characteristic Polynomials, Diagonalization of Matrices, Reduction to Triangular Forms, Jordan Blocks, Jordan Canonical Forms,	32

	Determinant divisors and Invariant Factors, Rational Canonical Forms, Smith Normal Form Over an Euclidean Domain.	
IV(Nov-Dec)	Bilinear Forms, Quadratic Forms, Hermitian Forms, Positve Definite Hermitian Forms &its Direct sum decomposition theorem, Pricipal Minor Criteron, Signature, Sylvester Law Of Inertia, Simultaneous Reduction of Pair of Forms.	32

Semester		**I**			
Course Title	**Real Analysis:**				
Course Code	**MTMP COR 03T**	**Credit**	**4**		
Course Outcome	Upon completion of this course, the student will be able to understand the basics of Real Analysis and improve the logical thinking.				
Scheme of Instruction					
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				

Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	Course Content	Lecture Hour (Cumulative)
I (July-August)	Functions of bounded variation: Definition and basic properties, Lipschitz condition, Jordan decomposition, Nature of points of discontinuity, Nature of points of non-differentiability, positive and negative variation and their properties.	24
II (August-Sep.)	The Lebesgue measure: Lebesgue Outer measure, countability, subadditivity, measurable sets and their properties, non-measurable sets, definition of Lebesgue measurable. Measurable functions: Definition on a measurable set in R and basic properties, Simple Functions.	24
III (September-Oct.)	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; Characterization of an absolutely continuous function in terms of its derivative vanishing almost everywhere, property (N), every absolutely continuous function possesses the property (N).	16
IV (Oct.-Nov.)	Differentiation on R^n:Functions from R^n to R^m, projection functions, component functions, scalar and vector fields, open balls and open sets, limit and continuity. Derivative of a scalar field with respect to a vector, directional derivatives and partial derivatives, partial derivatives of higher order, Chain rule,Frechet derivative, matrix representation of	16

	derivative of functions, continuously differentiable functions, Implicit function theorem, inverse function theorem.	
V (Nov-Dec)	Integration on R^n: Integral of f: $A \to R$ when $A \subset R^n$ is a closed rectangle. Conditions of integrability. Integrals of f: $C \to R$, $C \subset R^n$ is not a rectangle, concept of Jordan measurability of a set in R^n. Fubini's theorem for integral of f: $A \times B \to R$, $A \subset R^n$, $B \subset R^n$, are closed rectangles. Fubini's theorem for f: $C \to R^n$, $C \subset A \times B$. Formula for change of variables in an integral in R^n.	16

<table>
<tr><td colspan="3">Semester</td><td colspan="3"></td></tr>
<tr><td>Course Title</td><td colspan="5"></td></tr>
<tr><td>Course Code</td><td colspan="2"></td><td colspan="2">Credit</td><td></td></tr>
<tr><td>Course Outcome</td><td colspan="5"></td></tr>
<tr><td colspan="6">Scheme of Instruction</td></tr>
<tr><td>Total Duration</td><td></td><td>Class/Week</td><td></td><td>Hours/week</td><td></td></tr>
<tr><td>Instruction Mode</td><td colspan="5"></td></tr>
<tr><td colspan="6">Scheme of Examination</td></tr>
</table>

Maximum Score		Internal		End Semester	

Course Mapping		
Units	**Course Content**	**Lecture Hour (Cumulative)**

Semester	I		
Course Title	**Complex Analysis**		
Course Code	**MTMP COR 04T**	**Credit**	**4**

<table>
<tr><td>Course Outcome</td><td colspan="5">On completion of this course, the students will be able to identify, analyze, classify, demonstrate and explain the acquired knowledge mainly on the following :

i) Stereographic Projection, Riemann’s sphere, point at infinity, extended complex plane,

ii) Cauchy-Goursat Theorem, Cauchy’s integral formulas, Morera’s theorem, Liouville’s theorem,

iii) Fundamental theorem of classical algebra, Schwarz Reflection Principle, Maximum Modulus Principle,

iv) Cauchy-Hadamard Theorem, Taylor’s theorem and Laurent’s theorem,

v) Riemann’s Removal singularity thorem, Weierstrass-Casorati,

vi) The Cauch’s Residue Theorem, Argument principle and their applications,

vii) Conformal mapping, Bilinear transformation, Idea of analytic continuation.</td></tr>
<tr><td colspan="6">Scheme of Instruction</td></tr>
<tr><td>Total Duration</td><td>6 Months</td><td>Class/Week</td><td>4</td><td>Hours/week</td><td>4</td></tr>
<tr><td>Instruction Mode</td><td colspan="5">Lecture</td></tr>
<tr><td colspan="6">Scheme of Examination</td></tr>
<tr><td>Maximum Score</td><td>50</td><td>Internal</td><td>10</td><td>End Semester</td><td>40</td></tr>
<tr><td colspan="6">Course Mapping</td></tr>
</table>

Units	Course Content	Lecture Hour (Cumulative)

I (July-August)	Algebraic, Geometric and analytic preliminaries of complex numbers. Stereographic Projection, Riemann's sphere, point at infinity and its deleted neighbourhood, the extended complex plane.	24
II (August-Sep.)	Functions of a complex variable, Its Limit, Continuity and Differentiability. Analytic functions, Cauchy- Riemann equations. Branch of Logarithm, Complex integration, Winding Number or Index of a closed curve, The Cauchy-Goursat Theorem, its homotopic version (if time permits) and consequences. Cauchy's integral formula. Cauchy's integral formula for derivative, Morera's theorem, Cauchy's inequality, Liouville's theorem. Fundamental theorem of classical algebra, Schwarz Reflection Principle,.	24
III (September-Oct.)	Gauss's Mean Value Property, Maximum Modulus Theorem. Power series, The Cauchy-Hadamard Theorem, Analyticity of Power Series, Weierstrass theorem on Uniformly convergent series of analytic functions, Uniqueness Theorem. Taylor's theorem and Laurent's theorem, Zeros of an analytic function.	16
IV (Oct.-Nov.)	Classification of Singularities, Riemann's Removal singularity thorem, Weierstrass-Casorati theorem, Limit points of zeros and poles, Classification of Singularities at infinity.	16
V (Nov-Dec)	Calculus of residues, The Cauch's Residue Theorem. Argument principle, Rouche's theorem and Hurwitz's Theorem, Evaluation of definite integrals using residue theorem. Conformal mapping, Bilinear transformation, Idea of analytic continuation.	16

<table>
<tr><td colspan="2">Semester</td><td colspan="4">I</td></tr>
<tr><td>Course Title</td><td colspan="5">Mechanics</td></tr>
<tr><td>Course Code</td><td colspan="2">MTMP COR 05T</td><td colspan="2">Credit</td><td>4</td></tr>
<tr><td>Course Outcome</td><td colspan="5">1. Students will be able to apply the equations of motion to solve analytically the problems of motion of a

single particle/a system of particle or rigid body under conservative force fields.

2. Use the Hamilton’s principle for deriving the equations of motion of a system.

3. Gain knowledge of Hamiltonian system and phase planes from the point of view of mechanics.

4. Use the theory of normal modes for solving problems related to oscillations and vibrations.

5. Students will learn the basics of classical mechanics and STR required for further studies in solid and quantum mechanics.</td></tr>
<tr><td colspan="6">Scheme of Instruction</td></tr>
<tr><td>Total Duration</td><td>6 Months</td><td>Class/Week</td><td>4</td><td>Hours/week</td><td>4</td></tr>
<tr><td>Instruction Mode</td><td colspan="5">Lecture</td></tr>
</table>

Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	Course Content	Lecture Hour (Cumulative)
I(July)	Introduction, Kinematics for a single particle.Laws of Motion for a particle.Conservation principles. Principle of energy. Central forces and central orbits. System of particles. Generalised Co-ordinates. Constraints, unilateral, bilateral, holonomic, schleronomic, rheonomic. Principle of Virtual Work. D'Alembert's Principle. Lagrange's equations for Holonomic and Nonholonomic Systems. Lagrange's Equation of Motion. Energy Equation for Conservative Fields. Cyclic or Ignorable Co-ordinates. Routh's Equations.	16
II (August)	Hamilton's Equations of Motion. Calculus of Variations. Hamilton's Principle. Hamilton's and Lagrange's Equations of Motion form Hamilton's Principle. Principle of Least Action. Constants of Motion. Noether's Theorem. Conservation Laws. Dynamical systems. Liouville's theorem for conservative flow. Motion of a Rigid Body. Euler's Theorem. Motion about a Fixed Point in it. Euler's Dynamical Equations. Motion of a symmetric top in absence of torque. Eulerian angles. Motion of a Symmetrical top under gravity. Stability of Steady Precession.	16
III(Sep.-Oct.)	Canonical Transformations. Generating Functions. Poisson's Bracket. Jacobi's Identity. Poisson's	32

	Theorem. Jacobi-Poisson Theorem. Hamilton-Jacobi Partial Differential Equation. Jacobi's Theorem. Hamilton's Principal Function. Hamilton's Characteristic Function. Action Angle Variables. Adiabatic Invariance.	
IV (Nov-Dec)	Theory of Small Oscillations (Conservative System). Normal Co-ordinates. Oscillations under Constraints. Stationary Character of Normal Modes. Special Theory of Relativity. Galilean Transformation and the Speed of light. Lorentz Transformation. Time dilation and length contraction. Consequences. Velocity and acceleration transformation.4 – vectors. 4-velocity.4-acceleration.4momentum.Relativistic mass. Momentum and energy conservation inn STR.Collision.4-force.	32

Semester		**I**	
Course Title	**Computational Techniques and Introduction to LaTeX**		
Course Code	**MTMP AEC 01M**	**Credit**	**2**
Course Outcome	At the end of this course a student should be able to : • understand the purpose of basic computer programming language, • understand and apply control statements, implementation of arrays, functions, etc., • enhance ability to program writing skills for solving several real life and Mathematical problems, • use LaTeX and develop typeset documents containing tables,		

	figures, formulas, common book elements like bibliographies, indexes etc. and modern PDF features.					
Scheme of Instruction						
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4	
Instruction Mode	**Practical**					
Scheme of Examination						
Maximum Score	50	**Internal**	40	**End Semester**	10	
Course Mapping						

Units	**Course Content**	**Lecture Hour (Cumulative)**
I (July)	Programming Basics: Character set. Constants and variables data types, key words, expression, assignment statements, declaration. Arithmetic, relational and logical operators. Conditional operators.	16
II (Aug.)	Decision making : if statement, if-else statement, Nesting if statement, switch statement, break and continue statement, the Goto statement. Control Statements : While statement, do-while	16

	statement, for statement.	
III (Sep.- Oct.)	Arrays : One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays. Functions : Function declaration, Library and User defined function, Function argument. Recursion. Programming problems for all sections above (Separate and Combined).	32
IV (Nov- Dec)	**LaTeX** Document structure, Formatting text, math formulas and expressions, equations, tables, graphics,index, cite books, bibliography, Beamer presentation.	32

	Semester	**II**	
Course Title	**Topology**		
Course Code	**MTMPCOR06T**	**Credit**	**4**
Course Outcome	On completion of this course, the students will be able to identify, analyze, classify, demonstrate and explain the acquired knowledge on the following : i) Axiom of choice, Continuum hypothesis, Cardinal and Ordinal numbers, ii) Basics of Topological spaces, Relative topology, homeomorphism and topological properties , iii) Alternative methods of defining a topology in terms of Kuratowski closure operator, interior		

	operator and neighbourhood systems, iv) Countability axioms, Heinei's continuity criterion, v) Product and box topology, Tychonoff product theorem, vi) Quotient spaces, Local Connectedness, Path- connectedness, Total disconnectedness

Scheme of Instruction					
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				

Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	Course Content	Lecture Hour (Cumulative)
I (Jan)	Brief Description: Countable and uncountable sets. Axiom of choice and its equivalence. Cardinal numbers. Schroeder-Bernstein theorem. Continuum hypothesis. Zorn's lemma and well-ordering theorem. Ordinal Numbers. The first uncountable ordinal. Topological spaces, Open and Closed sets, Bases and sub-bases. Closure and Interior – their properties and relations; Exterior, Boundary,	16

	Accumulation points, Derived sets, Adherent point, Dense set, G_δ and F_σ sets. Neighboourhoods and neighbourhood system.	
II (Feb.)	Alternative methods of defining a topology in terms of Kuratowski closure operator, interior operator, neighbourhood systems. Subspace and Induced or Relative topology. Relation of closure, interior, accumulation points etc. between the whole space and the subspace. Continuous, open and closed maps, pasting lemma, homeomorphism and topological properties.	16
III (March)	1_{st} and 2_{nd} countability axioms, Separability, Lindeloffness and their relationships. Characterizations of accumulation points, closed sets, open sets in a 1_{st} countable space w.r.t.sequences .Heinei's continuity criterion . T_i spaces(i = 0, 1, 2, 3, 3½, 4, 5), their characterizations and basic properties. Urysohn's lemma and Tieze' extension theorem (statement only) and their applications.	16
IV (April)	Connected and disconnected spaces. Connectedness on the real line. Components and quasi-components. Compactness, its basic properties and characterizations, Alexander subbase theorem, Continuous functions and compact sets, Compactness and separation axioms . Equivalence of compactness, countable compactness and sequential compactness in metric spaces.	16
V (May-	Product and box topology, Projection maps. Tychonoff product theorem. Separation and product spaces. Connectedness and product spaces.	32

June)	Countability and product spaces. Identification topology and Qutient spaces. Local Connectedness, Path- connectedness, Total disconnectedness, Zero -dimensional spaces, Extremally disconnected spaces.	

Semester			**II**		
Course Title	**Functional Analysis**				
Course Code	**MTMP COR 07T**		**Credit**	**4**	
Course Outcome	On successful completion of this course, students will be able to appreciate howfunctional analysis uses and unifies ideas from vector spaces, the theory of metrics, and complex analysis. Moreover, students will be able to understand and apply fundamental theorems from the theory of normedand Banach spaces, Hilbert spaces.				
Scheme of Instruction					
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				
Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40
Course Mapping					

Units	Course Content	Lecture Hour (Cumulative)
I (Jan)	Metric spaces, Brief discussions of continuity, completeness, compactness, connectedness. Hölder and Minkowski inequalities (statement only). Baire's category theorem, Banach's fixed point theorem and its applications to solutions of certain systems of linear algebraic equations, Picard's existence theorem on differential equation, Implicit function theorem and Fredholm's integral equation of the second kind, Kannan's fixed point theorem.	16
II (Feb)	Real and Complex linear spaces. Normed induced metric. Banach spaces, the spaces R_n, C_n, C [a, b], C_0, C, lp(n)(1≤p≤∞), lp(1≤p≤∞) and [,] $_2 L\ a\ b$. Riesz's lemma. Finite dimensional normed linear spaces and subspaces, completeness, compactness criterion, Quotient space, equivalent norms and its properties.	16
III (March)	Bounded linear operators, various expressions for its norm. Spaces of bounded linear operators and its completeness. Inverse of an operator. Linear and sublinear functionals, Hahn-Banach theorem for real linear spaces, complex linear spaces and normed linear spaces and some of its simple applications.	16
IV (April)	Conjugate or Dual spaces, Examples, Separability of the Dual space. Reflexive spaces, weak and weak* convergence. Uniform boundedness principle and its applications. The Open mapping Theorem and the Closed graph Theorem.	16
V(May-	Inner product spaces and Hilbert spaces, examples of Hilbert spaces, continuity of inner product, CS	32

June)	inequality, basic results on Inner product spaces and Hilbert spaces, parallelogram law, Pythagorean law, Polarization identity, orthogonality, orthonormality, orthogonal complement. The Riesz representation theorem, Bessel's inequality. Convergence of series corresponding to orthogonal sequence, Fourier coefficient, Perseval identity. Riesz- Fischer Theorem.	

Semester			**II**		
Course Title	**Ordinary Differential Equations and Special Functions**				
Course Code	**MTMP COR 08T**		**Credit**	**4**	
Course Outcome	1 .Students will learn about existence and uniqueness of solutions and Picard's method of approximation . This can be directly applied for a numerical approximation. 2. Knowledge of the properties of eigenvalues and eigenfunctions will be useful in studying Mathematical physics. 3. An acquaintance with special functions will be useful for students interested in research in continuum mechanics or theoretical physics. 4. An acquaintance with special functions will be useful for students interested in research in continuum mechanics or theoretical physics. 5. Introductory ideas of phase plane analysis and stability can be utilised by students while studying dynamical systems or mathematical biology. areas of physics.				
Scheme of Instruction					
Total Duration	6 months	**Class/Week**	4	**Hours/week**	4

Instruction Mode	lecture				
Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40
Course Mapping					

Units	Course Content	Lecture Hour (Cumulative)
I (Jan)	First- order equations: Well-posed problems, existence and uniqueness of solution of the first order initial value problem .Cauchy Peano existence theorem. Lipschitz condition. Picard's method of successive approximations. Picard-Lindeloeff theorem. Continuation of solution. Dependence on parameters and on initial value. Existence and uniqueness theorems for systems of first order differential equations and higher order ordinary differential equations.	
II (Feb)	Theory of Linear systems and n th order linear ODE. System of linear homogeneous and non-homogeneous differential equations. Fundamental matrix. Exponential matrix function and their properties. Method of solving systems of linear ordinary differential equations by fundamental matrix and exponential matrix function. Equations with constant coefficients and periodic coefficients.	
III (March)	Nth order linear ordinary differential equations. Method of variation of parameters. Linear Autonomous System, Phase Plane Analysis, Equilibrium Points, Classification of equilibrium points, Stablility of equilibrium points .	

IV (April)	Adjoint and self-adjoint linear differential equations: Abel's identity, oscillatory solutions. Sturm's separation and comparison theorems. Eigenvalue problems , Sturm – Liouville problem, solution by Green's function. Eigenvalues and Eigenfunctions.Properties.FourierSeriesexpansion in terms of eigenfunctions.	
V(May-June)	Special Functions: Concepts of ordinary and singular points of a second order linear differential equation in a complex plane, Fuch's theorem, Solution at an ordinary point, Regular singular point, Frobenius Method, Solution at a regular singular point, Series solutions of Legendre and Bessel equations. Legendre polynomial: Generating function, Schlaffli'sintegral,Rodrigue's formula, recurrence relations, orthogonality property, expansion of a function in a series of Legendre polynomials. Bessel function and its properties.	

Semester		**II**	
Course Title	**Gr. A - Numerical Analysis ; Gr. B - Integral Transforms**		
Course Code	**MTMP COR 09T**	**Credit**	**4**
Course Outcome	After completion of the course, the student is expected to : • understand basic theories of numerical analysis,		

	• formulate and solve numerically problems from different branches of science, • grow insight on computational procedures, • learn theory and properties of Fourier transform, Laplace Transform and Z-Transform and their applications to relevant problems.				
Scheme of Instruction					
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				
Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40
Course Mapping					

Units	Course Content	Lecture Hour (Cumulative)
I (Jan)	Numerical Solution of System of Linear Equations: Triangular factorisation methods, Iterative methods :Jacobi method, Gauss-Seidel method and Gauss Jacobi method and their convergence ,diagonal dominance, Successive-Over Relaxation (SOR) method, Ill- conditioned matrix. Eigenvalues and Eigenvectors of Real Matrix: Power method for extreme eigenvalues and corresponding eigenvectors, Gerschgorin's circle theorem. Solution of Non-linear Equations: Newton-Raphson and secant method , rate of convergence , General iterative method for the	16

	system : x = g(x) and its convergence. Non-Linear Systems of Equations: Newton's method	
II (Feb)	Polynomial Interpolation: Weirstrass's approximation theorem (Statement only), Hemite interpolation, Cubic spline interpolation. Numerical Integration: Newton-Cotes formulae, Romberg integration. Numerical Solution of PDE : Finite Difference Methods, Heat equation, Crank-Nicolson method, five point formula for solving Laplace and Poissionequations. Wave equation: Explicit and Implicit method of solving Cauchy problem.	16
III (March)	The Fourier Transform: Fourier Integral Theorem. Derivation of Fourier transform from Fourier series, Properties of Fourier transform, Convolution, Transform of derivatives.	16
IV (April)	Fourier cosine and sine transforms. Inverse Fourier transform. Parseval's Identity. Finite Fourier Transform. Application to solving ordinary and partial differential equation.	16
V(May- June)	The Laplace transform: Definition and properties. Sufficient conditions for the existence of Laplace Transform. Transform of derivatives. Convolution theorem. Inversion of Laplace Transform. Evaluation of inverse transforms by residue. Initial and final value theorems. Heaviside expansion theorem. Applications of Laplace transform.	32

	The Z-Transform:Definition and properties. Z-transform of some standard functions. Inverse Z-transforms. Applications.	

Semester			**II**			
Course Title	**Differential Manifold**					
Course Code	**MTMP COR 10T**		**Credit**		**4**	
Course Outcome	On completion of this course, the students will be able to identify, analyze, classify, demonstrate and explain the acquired knowledge mainly on the following : i) tangent and cotangent spaces; submanifolds, ii) vector fields and their flows; the Frobenius Theorem, iii) multilinear algebra, differential forms, the Lie derivative, iv) Lie groups and Lie algebras, v) Integration on manifolds, theorems of Stokes, integration on a Lie group, vi) de Rham cohomology					
Scheme of Instruction						
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4	
Instruction Mode	**Lecture**					

Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping		
Units	**Course Content**	**Lecture Hour (Cumulative)**
I (Jan)	Differentiable manifolds: basic notions; the effects of second countability and Hausdorffness; tangent and cotangent spaces; submanifolds; consequences of the Inverse Function Theorem;	16
II (Feb)	Vector fields and their flows; the Frobenius Theorem; Sard's theorem. Differential forms: Multilinear algebra; tensors;	16
III (March)	Differential forms; the de Rham complex and its behaviour under differentiable maps; the Lie derivative; differential ideals.	16
IV (April)	Lie groups: Lie groups; Lie algebras; homomorphisms; Lie subgroups; coverings of Lie groups; the exponential map; closed subgroups; the adjoint representation; homogeneous manifolds.	16
V(May-June)	Integration on manifolds: orientation; the integral of differential forms on differentiable singular chains; integration of differential forms of top degree on an oriented 3 differentiable manifold; the theorems of Stokes; the volume form on an oriented Riemannian manifold; the divergence theorem; integration on a Lie group. de Rham cohomology: definition; real differentiable singular cohomology; statement of the de Rham theorem; the Poincar lemma.	32

Semester	II

<table>
<tr><td>Course Title</td><td colspan="6">Computer Aided Numerical Analysis using C/ Matlab/ Mathematica:</td></tr>
<tr><td>Course Code</td><td colspan="2">MTMP SEC 01M</td><td colspan="2">Credit</td><td colspan="2">4</td></tr>
<tr><td>Course Outcome</td><td colspan="6">At the end of this course a student should be able to :
• solve different type of numerical problems,
• understand better relevant theoretical concepts,
• apply programming skills in interdisciplinary areas such as biological system, physical system etc.,
• analyze data set of various size and interpret outcomes helping her/him to compete in the financial
sector.
• apply programming skills in graphics animation, computerized abstract art.</td></tr>
<tr><td colspan="7">Scheme of Instruction</td></tr>
<tr><td>Total Duration</td><td>6 Months</td><td>Class/Week</td><td>4</td><td>Hours/week</td><td colspan="2">4</td></tr>
<tr><td>Instruction Mode</td><td colspan="6">Lecture</td></tr>
<tr><td colspan="7">Scheme of Examination</td></tr>
<tr><td>Maximum Score</td><td>50</td><td>Internal</td><td>40</td><td>End Semester</td><td colspan="2">10</td></tr>
<tr><td colspan="7">Course Mapping</td></tr>
<tr><td>Units</td><td colspan="3">Course Content</td><td colspan="3">Lecture Hour (Cumulative)</td></tr>
</table>

I (Jan)	Cubic spline interpolation.. Gauss Elimination Method for a System of Linear Equations.	16
II (Feb)	Newton's Method for a System of Nonlinear Equations. Inverse of a matrix.	16
III (March)	Integration by Romberg's method. Largest Eigen values of a real matrix by power Method.	16
IV (April)	Numerical Solutions of Ordinary Differential Equations for Initial Value Problems : (a) Picard's Formula, (b) Adams-Bashforth method, (c) Milne's predictor–corrector method.	16
V(May-June)	Finite Difference Method for PDE – Elliptic Type PDE, Parabolic Type PDE, Hyperbolic Type PDE.	32

Semester		**III**	
Course Title	**Partial Differential Equations and Calculus of Variations**		
Course Code	**MTMP COR 11T**	**Credit**	**4**
Course Outcome	At the end of this course a student should be able to : • learn to solve different types of PDE, • test the stability of the solution, • apply PDE to problems of geometry and physics, • understand basic theories of calculus of variations,		

<table>
<tr><td></td><td colspan="5">• formulate and solve problems from allied branches of science.</td></tr>
<tr><th colspan="6">Scheme of Instruction</th></tr>
<tr><td>Total Duration</td><td>6 Months</td><td>Class/Week</td><td>4</td><td>Hours/week</td><td>4</td></tr>
<tr><td>Instruction Mode</td><td colspan="5">Lecture</td></tr>
<tr><th colspan="6">Scheme of Examination</th></tr>
<tr><td>Maximum Score</td><td>50</td><td>Internal</td><td>10</td><td>End Semester</td><td>40</td></tr>
<tr><th colspan="6">Course Mapping</th></tr>
</table>

Units	Course Content	Lecture Hour (Cumulative)
I(July)	Origins of Partial Differential Equations(PDE). Linear and non- linear PDE. Cauchy's method of characteristics ,Charpit's method, Jacobi's method. Second order PDE with constant and variable coefficients. Reduction to canonical forms and Classification, characteristic curves.	16
II (August)	Well-posed and ill-posed problems. Non linear PDE of second order. Wave equation: vibrations of strings, D'Alembert's solution, Riemann's method, Solution by separation of variables, Transverse vibrations of membranes.	16
III(Sep.-Oct.)	Laplace Equation: Equipotential surfaces, Boundary value problems, Maximum-minimum principles, The Cauchy problem, Stability of the	32

	solution. Theory of Green's function. Diffusion equation: Boundary value problems, variables separable solution. Duhamel's Principle. Solution of linear partial differential equations by Lie algebraic method.	
IV (Nov-Dec)	Linear functional, Euler equation, The Brachistochrone problem: Cycloid, Geodesic, Several dependant variables : Lagrange's equations, Isoperimetric problem, Variational problems : parametric form , with moving boundaries, least action principle.	32

Semester		**III**			
Course Title	**Nonlinear Differential Equations and Dynamical Systems:**				
Course Code	**MTMP COR 12T**		**Credit**	**4**	
Course Outcome	1. On the completion of this course students will be able to study the nature linear stability and general stability of critical points and solutions ; also investigate the existence of periodic solutions ; and identify a bifurcation through change of parameters ; further, have a basic idea of perturbation methods. 2. These methods can be applied by the students to study problems of population biology and nonlinear wave propagation.				
Scheme of Instruction					
Total Duration	6	**Class/Week**	4	**Hours/week**	4

	Months				
Instruction Mode	**Lecture**				
Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40
Course Mapping					

Units	Course Content	Lecture Hour (Cumulative)
I(July)	System of ODE's Autonomous System, Phase Plane Analysis, Equilibrium Points, Classification of equilibrium points, Stablility of equilibrium points. Nonlinear autonomous systems. Flow diagram, Phase portrait, Isocline. Fixed points and their nature. stability, asymptotic stability, Linearization about a critical point. Liapunov function.	16
II (August)	Conservative systems. Hamiltonian systems. Index of an equilibrium point. The index at infinity. The phase diagram at infinity. Homoclinic and heteroclinic paths. Limit cycles and other closed paths.	16
III(Sep.-Oct.)	. Averaging methods. Energy balance method for limit cycles. Amplitude and frequency estimates. Nearlyperiodic solutions. Periodic solutions and Harmonic balance method. Perturbation methods for Duffing;s equation. Peridic solution of autonomous systems. Lindstedst's method. Singular perturbation. Lighthills method.	32
IV (Nov-	Stability. Poincare and Lyapunov stability. Solutions and paths, linear systems, zero solutions of nearly linear systems. The existence	32

Dec)	of periodic solutions. The Poincare Bendixson theorem. Simple bifurcations. The saddle-node, transcritical and pitchfork bifurcation. Hopf bifurcation.Manifolds. Stable Manifold and Centre manifold theorem.	

Semester			**III**		
Course Title	**Gr. A-Electromagnetic Theory ; Gr. B- Integral Equations:**				
Course Code	**MTMP COR 13T**		**Credit**	**4**	
Course Outcome	After completing this course, the student will be able to: • build up strong application capability of graduate level mathematics, • understand and apply the basic theories of electromagnetism, • get an exposure to the Einstein's Theory of Relativity, • grow interest in electrical engineering, • distinguish between differential and integral equations, • understand the theory of existence and uniqueness of solutions of linear integral equations, • find solutions of linear integral equations of first and second type (Volterra and Fredhlom) and singular integral equations using several techniques.				
Scheme of Instruction					
Total Duration	6	**Class/Week**	4	**Hours/week**	4

	Months				
Instruction Mode	**Lecture**				
Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	Course Content	Lecture Hour (Cumulative)
I(July)	Electrostatics: Coulomb's law, Electric Field, Divergence and Curl of Electrostatic Fields, Gauss' law,Electric Potential: Poisson and Laplace equation, Work and Energy, Conductors. Electric Fields in Matter: Polarization, Electric Displacement, Linear Dielectrics. Magnetostatics: Lorentz Force Law, Steady currents, Biot-Savart Law, Divergence and Curl of B, C Magnetic Vector Potential. Magnetic Fields in Matter: Field of a Magnetized Object, Ampere's Law in Magnetized Material, Linear and Nonlinear Media.	16
II (August)	Electromagnetic Induction: Faraday's Law, Maxwell's Equations. Conservation Laws, Continuity Equation, Poynting's Theorem. Newton's Third Law in Electrodynamics, Maxwell's Stress Tensor, Conservation of Momentum. Electromagnetic Waves in Vacuum and Matter, Fresnel's equations, Absorption and Dispersion, Guided Waves. Coulomb Gauge and Lorenz Gauge, Jefimenko's Equations, Dipole radiation, Radiation reaction. Relativistic electrodynamics : Einstein's postulates , Lorentz transformation, Magnetism as a Relativistic	16

	phenomenon, Field transform, Field tensor, Relativistic potential.	
III(Sep.-Oct.)	Definition of Integral Equation and their classification. Reduction of differential equation to integral equation and vice-versa. Eigen values and Eigen functions. Existence and uniqueness of solutions of Fredholm and Volterra integral equations of second kind. Solution by the method of successive approximations, series solution. Iterated kernels.	32
IV (Nov-Dec)	Reciprocal kernels. Neumann series. Solution of integral equations with separable kernels. Solution of Volterra integral equation of first kind. Fredholm theorems and Fredholm Alternative. Hilbert-Schmidt theory of integral equations for symmetric kernels. Singular Integral equation, Solution of Abel's Integral equation. Solution of Volterra equation of convolution type by Laplace transform.	32

Semester		**III**	
Course Title	**Measure and Integration**		
Course Code	**MTMP COR 14T**	**Credit**	**4**
Course Outcome	i.) Lebesgue measure, Vitali's theorem concerning existence of non-measurable sets, ii) measurable functions, Theorem relating to non negative μ-measurable function as a limit of a monotonically increasing sequence of non negative simple μ-measurable functions, iii) Lebesgue's monotone convergence theorem and its applications, Fatou's lemma, Lebesgue's dominated convergence Theorem, iv) Interrelation between Riemann & Lebesgue integration,		

	v) Concept of L_p-spaces and its completeness, vi) Characterizations of Convergence in Measure, Almost Uniform Convergence, Egoroff theorem, vii) Product Measure. Fubini’s Theorem, viii) Signed Measure and the Hahn Decomposition, Radon-Nikodym Theorem.

Scheme of Instruction

Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				

Scheme of Examination

Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	Course Content	Lecture Hour (Cumulative)
I(July)	Outer Lebesgue Measure m_* in the Euclidean line and its Properties. Outer measure $\boldsymbol{\mu}_*$ on S, where S is a space; the concept of μ-measurable sets with the help of $\boldsymbol{\mu}_*$. Necessary and sufficient condition for μ- measurability. Properties of **μ**-measurable sets. The structure of μ-measurable sets-the concept of σ- algebra; the σ-algebra of Lebesgue measurable sets.	16

II (August)	Properties of Lebesgue measure, Vitali's theorem: The existence of an non-measurable set in the Euclidean line . The Borel sets & Lebesgue measurable sets- a comparison μ-measurable functions, their properties; Characteristic functions, Simple functions. Theorem relating to the non negative μ-measurable function as a limit of a monotonically increasing sequence of non negative simple μ-measurable functions.	16
III(Sep.-Oct.)	Lebesgue Integration : Integration for simple functions and for Extended real valued **μ**-measurable functions; The countable additivity of the set of function ν_f on **M** defined by $\nu_f(M) = \int_M f$, for each set M Є **M** , the **σ**- algebra of μ-measurable sets, for a nonnegative **μ**-measurable function f ; Lebesgue's monotone convergence theorem and its applications, Fatou's lemma, Lebesgue's dominated convergence Theorem. Necessary & Sufficient condition of Riemann integrability via measure; interrelation between the two modes of integration.	32
IV (Nov-Dec)	The Concept of L_p-spaces; Inequalities of Holder and Minkowski; Completion of L_p-spaces. Convergence in Measure, Almost Uniform Convergence, Pointwise Convergence a.e and their Characterizations; Convergence Diagrams, Counter Examples. Egoroff theorem. Lebesgue Integral in the Plane. Product σ-algebra. Product Measure. Fubini's Theorem. If time permits :Signed Measure and the Hahn	32

	Decomposition; The Jordan Decomposition. The Radon-Nikodym Theorem.	

Semester				**III**		
Course Title	**Magneto-hydrodynamics**					
Course Code	MTMP DSE 01T		**Credit**	**4**		
Course Outcome	At the end of this course a student should be able to : • describe the properties of Magneto-hydrodynamic equations, • explain MHD waves, • apply the MHD equations to a number of astrophysical problems as well as to problems related to laboratory physics.					
Scheme of Instruction						
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4	
Instruction Mode	**Lecture**					
Scheme of Examination						
Maximum Score	50	**Internal**	10	**End Semester**	40	
Course Mapping						

Units	Course Content	Lecture Hour (Cumulative)

I(July)	Basic ideas of electro-magnetic fields, basic laws. Maxwell's equation,- in vacuum , in matter, physical significance, boundary conditions ; Energy transfer and Poynting theorem.	16
II (August)	Equation of motion of a conducting fluid, simplification of MHD equations using dimensional consideration (i.e. MHD approximations), magnetic Reynold's number, Alfven's theorem, the magnetic body force, Ferraro's law of isorotation, Non-dimensional form of the equation.	16
III(Sep.-Oct.)	Steady laminar flow of a viscous conducting fluid between parallel walls in the presence of a transverse magnetic field (i.e. Hartmann flow), Two dimensional MHD equations, Couette flow, Transient Couette flow, Flow through a rectangular duct. Unsteady incompressible flows, Rayleigh's problem.	32
IV (Nov-Dec)	Magnetohydrostatics, equilibrium configurations, Pinch effect, force-free fields, non-existence of force free field of finite extent. General solution for a force free field. The generalized Hugoniot condition. The compressive nature of magneto hydrodynamic shocks. Mach number, Subsonic and supersonic flows. Sub and super	32

	Alfvenic waves.	

Semester			**IV**		
Course Title	**Graph Theory**				
Course Code	MTMP COR 15T		**Credit**	**4**	
Course Outcome	After the course the student will have a strong background of graph theory. The students will be able to apply principles and concepts of graph theory in practical situations such as computer science, physical and engineering sciences.				
Scheme of Instruction					
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				
Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40
Course Mapping					

Units	**Course Content**	**Lecture Hour (Cumulative)**
I(Jan)	Undirected graphs, Directed graphs, Geometrical representation of graphs, Handshaking lemma due to Euler and some basic properties of a graph. In - degree and out - degree of a vertex in a digraph. Simple digraph and underlying graph. Representation of binary relations on finite sets by digraphs. Reflexive, symmetric and transitive digraphs. Sub graph, spanning sub graph,	16

	induced sub graph on a vertex set and induced sub graph on an edge set. Isomorphism of graphs. Walks, paths, circuits and cycles with their properties, concatenation of two walks.	
II (Feb)	Connected and disconnected graphs. A necessary and sufficient condition for a graph to be disconnected. Component of a graph, decomposition of a graph into finite number of components, acyclic graph and cycle edge of a graph. Some properties of connected graphs. Complete graphs, disconnecting sets, bridge, separating sets, distance between two vertices of a graph. Complement of a graph, Self complementary graphs, Ramsey problem. Bipartite graph and its characterization, radius and center, Diameter, Degree sequence.	16
III(March)	Eulerian and Hamiltonian graphs: Euler trials, Euler circuits, Edge traceable graphs, Euler graphs, Euler's Theorem. Fleury's algorithm, Konigsberg bridge problem. Hamiltonian path, Hamiltonian cycle, Hamiltonian graph. A necessary condition for the existence of a Hamiltonian cycle in a connected graph. Sufficient condition for a simple connected graph to be Hamiltonian. Dirac's Theorem, Ore's Theorem and its use.	16
IV (April)	Trees and forests with their properties. Minimally connected graphs, spanning trees. weighted graphs, weight of a spanning tree and minimal spanning trees, Kruskal's algorithm for a minimal spanning tree. The shortest path problem, traveling salesman problem.	16

V (May-June)	Matrix representation of graphs, adjacency matrices of graphs and digraphs and their properties, path matrix, incidence matrices of graphs and digraphs and their properties. Cut vertices and cut edges, Vertex and edge connectivities, Blocks, Clique Number, Independence number, Matching number. Chromatic number, Chromatic polynomial, edge colouring number, planar graphs, Kuratowski's two graphs, the Euler polyhedron formula, Euler identity for connected planar graphs, detection of planarity, Statement of Kuratowski Theorem, Isomorphism properties of graphs, 5 colour theorem. Statement of 4 colour theorem, Dual of a planar Graph.	32

Semester			**IV**		
Course Title	**Quantum Mechanics**				
Course Code	MTMPDSE 02T		**Credit**	**4**	
Course Outcome	At the end of this course a student should be able to : • Understand the fundamentals of quantum mechanics, • Create better grasp on different branches of mathematical physics, • Provide an opportunity to recapitulate application of higher pure mathematics, • Open the gateway to modern electronics and nano science.				
Scheme of Instruction					
Total Duration	6	**Class/Week**	4	**Hours/week**	4

	Months				
Instruction Mode	**Lecture**				

Scheme of Examination

Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	Course Content	Lecture Hour (Cumulative)
I(Jan)	Experimental background of quantum mechanics; deBroglie waves, Wave-particle duality; Wave functions and Schrodinger equation; Uncertainty relation. Statistical interpretation of wave functions, expectation values, Ehrenfest's theorem; Time-independent Schrodinger equation; Energy eigenfunction : Discrete and continuous energy eigenvalues; Infinite and finite square well problems: Parity, Simple harmonic oscillator: Algebraic and analytic methods of solution, Dirac delta function potential, free particle: wave packets.	16
II (Feb)	Representation of observables, Dirac's bra-ket notations, mathematical set up on Hilbert space. Equations of motion: Schrodinger picture, Heisenberg picture, Interaction picture. The Hydrogen atom, angular momentum, spin. Rotation, angular momentum and unitary groups, Generators of U(n) and SU(n), representation in terms of coordinate and momenta. Clebsch-Gordan coefficients, Wigner-Eckart theorem. Space inversion, time reversal. O(4) symmetry of Hydrogen atom.	16

III(March)	Identical particles, Bosons, Fermions; Pauli exclusion principle; Solids: Free electron gas, Band structure. Quantum statistical mechanics: Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distributions. Blackbody spectrum.	16
IV (April)	First and second order perturbations, degenerate perturbation theory. Fine structure of Hydrogen, spinorbit coupling, Zeeman effect.	16
V (May-June)	Variational method: Rayleigh-Ritz variational principle; Hydrogen molecule ion, ground state of helium atom. Relativistic quantum mechanics: Klein-Gordon equation, plane wave solution. Dirac equation, covariant form, charged particle in electromagnetic field, equation of continuity. Dirac hole theory. Spin of the Dirac particle.	32

Semester		**IV**	
Course Title	**Mathematical Biology**		
Course Code	MTMPDSE 03T	**Credit**	**4**
Course Outcome	After completion of this course, students should be able to formulate realistic mathematical models for diverse biological phenomena and analyse them mathematically to explain the observations as obtained from experiments, clinical trials and observations. • Students would learn to mathematically predict the outcome in a situation by constructing and theoretically analysing a model. • The students will learn how to develop mathematical models		

	which provide ways to design and evaluate protocols to manage and control animal populations, natural resources like forests, wildlife, fisheries, and outbreak of diseases.				
Scheme of Instruction					
Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				
Scheme of Examination					
Maximum Score	50	**Internal**	10	**End Semester**	40
Course Mapping					

Units	Course Content	Lecture Hour (Cumulative)
I(Jan)	A. Mathematical Models of Population Biology or Ecology 1. Deterministic models. Continuous growth models. Logistic growth law. Allee effect. Bacterial growth. Harvesting. Functional responses. The spruce budworm population.	16
II (Feb)	Models of interacting populations. The Lotka-Volterra model for competition. Competition between n species. The Lotka Volterra predator –prey model.Complexity and stability in a generalised predator-prey system.Predator-prey models with logistic growth in prey and Holling-type responses. Analysis of such models with limit cycle periodic behaviour. Mutualism.Host parasite	16

	model.	
III(March)	Stochastic processes and stochastic models. Pure birth process, Pure death process, Birth and death process. Linear birth-death-immigration-emigration processes. Effects of both immigration and emigration on the dynamics of population.	16
IV (April)	3. Biological mechanisms responsible for "time-delay". Discrete and continuous time-delay. The single species logistic model with the effect of time-delay. Stability of equilibrium position for the logistic model with general delay function. Stability of logistic model for discrete time lag. Time-delayed H-P model together with their stability analysis. 4. Spatial population models. Metapopulations. Reaction-diffusion model. Models for animal dispersal. 5. Biological waves. Single -species model. Fisher-Kolmogoroff equation and travelling wave solutions.	16
V (May-June)	B. Models of Epidemics. Introduction; Some basic definitions. Simple epidemic model, General epidemic model. Kermack- McKendrik threshold theorem. Recurring epidemic model. A comparative study of these models. Control of an epidemic. Stochastic epidemic model without removal. Models having multiple infections. Epidemic model with multiple infections. Stochastic epidemic model with removal. Stochastic epidemic model with removal, immigration and emigration. Special discussion on the stochastic epidemic model with carriers.	32

	Simple extensions of SIR model: Different case studies --- (i) Loss of immunity, (ii) Inclusion of immigration and emigration, (iii) Immunization. SIR endemic disease model.	

Semester	**IV**

Course Title	**Advanced Fluid Dynamics**		
Course Code	MTMPDSE 04T	**Credit**	**4**

Course Outcome	1. This course introduces fundamental ideas of fluid dynamics which can be further applied to problems of mechanical engineering. 2. On completion of this course, students would be able to enter research work in Advanced Fluid Theory and Computational Fluid Dynamics (CFD).

Scheme of Instruction

Total Duration	6 Months	**Class/Week**	4	**Hours/week**	4
Instruction Mode	**Lecture**				

Scheme of Examination

Maximum Score	50	**Internal**	10	**End Semester**	40

Course Mapping

Units	**Course Content**	**Lecture Hour (Cumulative)**

I(Jan)	Two and Three dimensional Inviscid incompressible fluid flow : : Field equations; Irrotational motion in simply connected and multiply connected regions. Source, sink,doublet. Image systems. Motion of solid bodies in fluid. Axi-symmetrical motion, Stokes' stream function, Two dimensional motion.	16
II (Feb)	Stream function, complex potential, motion of translation and rotation of circular and elliptic cylinders in an infinite liquid, Ciculation. Kelvin's Theorem. Cyclic and acyclic motion. Superposition of motion, circle theorem, Blasius theorem, KuttaJoukowski's theorem. Surface waves, progressive waves in deep and shallow water, Stationary waves, energy and group velocity.	16
III(March)	Viscous incompressible fluid flow: Similarity, Reynold's number, Flow between parallel plates. Couette and plane Poiseuille flow. Flow through pipes of circular, annular and elliptic cross sections. 4. Laminar Boundary layer.	16
IV (April)	Inviscid compressible flow : Field equations, Circulation, Propagation of small disturbance. Machn number and cone, Bernoulli's equation. Irrotational motion, Velocity potential. Bernoulli's equation interms of Mach number.	16
V (May-June)	Pressure, density, temperature in terms of Mach number, Critical conditions. Steady channel flow, Area-velocity relation. Mass flow through a converging nozzle. Flow through a de- Laval nozzle. Normal shock waves, Governing equations and the solution. Viscous compressible flow: Field equation of	32