Maulana Azad National Urdu University

Syllabus

M.Sc. (Mathematics)

Course Title : Real Analysis **SEM-1**
Course Code : MSMM101CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
This course on Analysis is a core course which will develop a deeper and rigorous understanding of Real Analysis, Calculus and Complex analysis. Concept of Metric Spaces, Continuity, Derivative and Integration are introduced. Introduction to Measure Theory and related theorems such as Fatou's Lemma, Monotone Convergence theorem are stated and proved.

Course Outcomes:
Upon completion of this course, the student should be able to get a foundation in Metric Spaces and Measure Theory. Concepts of Limit, Continuity, Differentiability and Lebesgue & Riemann Integration will be taught which are essential mathematical concepts.

Unit	Course Content	Instruction Hours
1	Metric Spaces- Limit Points, Closed Sets, Open Sets Perfect Sets, Bounded Sets, Closure of a Set, Compact Sets and Connected Sets. Limits of Functions – Continuous functions in Metric Spaces, Characterization of continuity in terms of Open sets and Closed sets – Continuity and Compactness- Continuity and Connectedness.	15
2	Derivative of a real function - Mean Value theorems- Continuity of Derivatives. Definitions of the Partition of Closed Interval, Refinement, Existence of the Riemann Stieltjes Integral, Necessary and Sufficient condition for Integrability, Integral as a limit of Sum, Integrability of Continuous, Monotonic, discontinuous, composite functions, Properties of the Integral , Integration and Differentiation.	15
3	Algebra of sets, Lebesgue Measure, Introduction, Outer measure, Measurable sets and Lebesgue Measure. Non-measurable set, Measurable functions, Littlewood's three principles.	15
4	Lebesgue Integral – The Riemann Integral, the Lebesgue Integral of a bounded function over a set of finite measure, Fatou's Lemma, Monotone Convergence theorem, the integral of a non negative function, the general Lebesgue Integral, Convergence in measure.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:

1.	Principles of Mathematical Analysis 3rd Edition Mc Graw-hill International Editions.	Walter Rudin
2.	Real Analysis 3rd Edition The Macmillan co., New York.	H.L. Royden
3.	Mathematical Analysis	S.C. Malik & Savita Aurora.
4.	Mathematical Analysis	T.M. Apostal.

Course Title : Linear Algebra **SEM 1**
Course Code : MSMM102CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objective of the course is to provide students with a good understanding of the concepts and methods of linear algebra by explaining with examples and related theorems the concept of Vector Spaces, Subspaces, Quotient Space, Linear dependence, Basis and Dimension. Introduce to the Linear Transformations, Matrix Theory and their applications. Cayley – Hamilton theorem, Results on Characteristic and minimal polynomial related to eigen values and Eigen vectors, Rational decomposition theorem, Cyclic spaces, Inner Product Space, Unitary, Adjoint , Hermitian Adjoint, Skew Hermitian , Normal Linear Operators.

Course outcomes:
On completion of the course students develop the ability to solve problems using linear algebra and will be able to connect linear algebra to other fields both within and without mathematics and will learn a number of applications of linear algebra. Further, the students will be able to develop abstract and critical reasoning by studying logical proofs and the axiomatic method as applied to linear algebra.

Unit	Course Content	Instruction Hours
1	Vector Spaces – Definition and examples, Subspaces, related theorems and problems, Quotient Space, Linear dependent and independent set of vectors, Basis and Dimension, Linear Transformation, Rank and Nullity of Linear Transformation, Sylvester's Law of Nullity.	15
2	Algebra of Linear Transformations- Hom(U, V) , Dual Space , Bidual , Matrix of a Linear Transformation , Change of Basis Equivalent and Similar Matrices, Dimension of Hom(U,V), Isomorphism between link of all linear transformation on a vector space and ring of all n X n matrices over F. Invertible Linear Transformations.	15
3	Eigen Values, Eigen Vectors, Characteristic polynomials, Minimal Polynomials of linear transformations, Cayley – Hamilton theorem, Results on Characteristic and minimal polynomial related to Eigen values and Eigen vectors, Rational decomposition theorem, cyclic spaces, companion matrix, Jordan Blocks and Jordan canonical forms.	15

4	Inner Product Space, Unitary, Adjoint, Hermitian Adjoint, Skew Hermitian, Normal Linear Operators.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:

1.	Topics in Algebra.	I.N. Herstein
2.	Linear Algebra with Problems	P.R. Halmos
3.	Linear Algebra	Hoffman & Kunze
4.	Modern Algebra	Surjeet Singh & Q Zameeruddin

Course Title : Ordinary Differential Equations **SEM 1**
Course Code : MSMM103CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
It is often seen that mathematical models are formulated in terms of equations involving functions as well as their derivatives. Such equations are called differential equations. The course covers the understanding of differential equations and their solutions with the initial and boundary conditions. The course also covers the method of series solution of differential equations.

Course Outcomes:
Upon completion of this course, the student should be able to: find solutions of initial and boundary value problems. The student will be able to find series solution of second order linear differential equations.

Unit	Course Content	Instruction Hours
1	Introduction – Initial Value Problem, Boundary Value Problem, Existence and Uniqueness theorem, Homogeneous and Non Homogeneous equations with constant coefficients. Theory of Equations with variable coefficients. Method of variation of parameters and the formula of particular integral in terms of Wronskian.	15
2	Series solution of second order linear differential equation- Regular singular points and the solution in the neighborhood of regular singular points, Euler's equation, Solution of Legendre, Bessel's, Hypergeometric, Hermite and Laguerre differential equations.	15
3	Existence and Uniqueness of solutions to first order equations – Method of successive approximations, Lipschitz condition, Non – local existence of solutions, systems as vector equations, Existence and Uniqueness of solution to systems and Existence and uniqueness of solution for linear systems.	15
4	Linear homogeneous boundary value problems, Eigen values and Eigen function, Strum- Liouville boundary value problem. Non homogeneous boundary value problem, Green's functions and the solution of boundary value problem in terms of Green's function.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:		
1.	An Introduction to Ordinary Differential Equations	Earl . A . Coddington
2.	Elementary Differential Equations and Boundary value problems.	Boyce and D.Prime
3.	Text Book of Ordinary Differential Equation 2nd edition, Tata McGraw Hill , New Delhi.	S.C Deo , Y . Lakshminathan & V Raghavendra

Course Title : Probability and Statistics(DSE) **SEM 1**
Course Code : MSMM104CCT

Scheme of Instruction		**Scheme of Examination**	
Total Duration	: 60 Hr	Maximum Score	: 100
Periods /Week	: 4	Internal Evaluation	: 30
Credits	: 4	End Semester	: 70
Instruction Mode	: Lecture	Exam Duration	: 3 Hrs

Course Objectives:
This course is designed to teach students the basic principles of probability & statistics and its application. Concept of Random sample, Probability, Conditional probability will be explained with examples. Baye's theorem and its implications will be discussed. Introduction to various discrete and continuous random variables, sampling theory will be given. Formulation of Null and Alternative hypothesis, tests on small and large samples explained with examples from diverse disciplines. Various statistical distributions such as Normal and Binomial.

Course outcomes:
By the end of this course students should be able to understand the common statistical techniques and terminology, the students will understand the basic principles of probability and their application and get familiar with the common probability distributions.

Unit	Course Content	Instruction Hours
1	Random experiments, Sample spaces, Sets, Events, Algebras. Elements of combinatorial analysis. Classical definition and calculation of Probability, Independence of events. Theorems on Probability- Boole's Inequality, Conditional Probability, Multiplication theorem of Probability-Baye's theorem.	15
2	Random variables; Distribution functions, Moments, Probability and Moment generating functions, Independence of random variables. Introduction to various discrete and continuous random variables, Limiting distributions of some random variables.	15
3	Sampling Theory – Types of sampling , Tests of significance – Null and Alternative hypothesis – Errors in sampling- Critical Region and Level of Significance –Tests on large samples-One-tailed and Two-tailed tests ,Sampling of Attributes, Test of significance for single proportion and for difference of proportions, Tests of significance of single mean and for difference of means.	15
4	Tests on small samples –The t- Distribution, Z- test for correlation, The F- distribution and Variance Ratio test. Chi Square Distribution- Limiting form of χ^2- distribution. Chi Square test of independence, chi square test of goodness of fit.	15

Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References :		
1.	Fundamentals of Mathematical Statistics	S.C Gupta and V.K. Kapoor.
2.	An Introduction to Statistical Methods	C B Gupta and Vijay Gupta.
3.	Handbook of Applied Statistics (Willey)	Chakravarthy, I.M
4.	Introduction to Probability Theory and its Applications (Willey - Eastern).	Feller, W.

Course Title : Algebra **SEM 2**
Course Code : MSMM201CCT

Scheme of Instruction

Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination

Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:

Objectives of this course are to give an introduction to Group Theory and study groups of prime order, Finite Abelian Groups, Invariants of finite Abelian groups, solvable groups, Further, to give an introduction to Rings, Integral domains, Fields, Ideals and Quotient rings, Unique factorization in F[x], Prime fields and Unique factorization domains.

Course outcomes:

On completion of this course the students will get a good understanding of Group Theory, Rings, Fields. The student will demonstrate the ability to investigate, interpret and give proofs of important theorems of Algebra. They will analyze a wide variety of patterns and functional relationships using the language of mathematics.

Unit	Course Content	Instruction Hours
1	Groups – Normal subgroups and Quotient Groups, Homomorphisms, Isomorphism theorems, Permutation and Cyclic groups , Cauchy's theorem for Abelian groups, Automorphisms , Cayley's theorem, Conjugacay, Another counting principle.	15
2	Sylows theorems, groups of p^2 and pq, Direct Products, Finite Abelian Groups – Finitely generated Abelian groups, Invariants of finite Abelian groups, solvable groups, Nilpotent groups.	15
3	Rings – Definition and examples, Integral domains, Fields, Ideals and Quotient rings, The field of Quotients of Integral domain, Rings of Polynomials, Evaluation homomorphism, Factorization of polynomials over a field, The Division Algorithm in F[x], irreducible polynomials, Eisenstein criterion, Unique factorization in F[x], Prime fields.	15
4	Factorization – Unique factorization domains, Every PID is a UFD, If D is a UFD then D[x] is a UFD. Euclidean domains and arithmetic in Euclidean domains, Gaussian integers and Multiplicative Norms	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:

1.	Topics in Algebra	I.N. Herstein
2.	A first course in Abstract Algebra	John B. Fraleigh.
3.	Basic Abstract Algebra, 2nd edition , Cambridge University Press	P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul

Course Title : Topology **SEM 2**
Course Code : MSMM202CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The prerequisite for the course is a first course in Analysis, at the level of Rudin's "Principles of Mathematical Analysis". In this course the students will be introduced the basic concepts of Topology. Definitions and examples of Topological Spaces, Open Bases, Open covering, Compact spaces, Hausdorff spaces, Separable spaces and totally disconnected spaces will be discussed. Proofs of important theorems such as Lindelof's Theorem, Tychnoff's Theorem, Ascoli's Theorem. Urysohn's Lemma and The Tietze Extension Theorem will be discussed.

Course outcomes:
In mathematics, topology is concerned with the properties of space that are preserved under continuous deformations, such as stretching, crumpling and bending, but not tearing or gluing, hence Topology is also known as rubber sheet geometry. On completion of the course students will understand that many concepts such as continuity, connectedness, compactness etc. are invariant under deformation of stretching and shearing. This course will give an insight into the beauty of mathematical argument and into qualitative approach to problem solving.

Unit	Course Content	Instruction Hours
1	Topological Spaces –Definition and Examples of Topological Spaces, Elementary concepts, Open bases and Open sub bases, Lindelof's theorem , Weak topologies and the function algebras C(X, R) and C(X, C).	15
2	Compact Spaces – Open covering and Compact spaces, continuity and compactness, Heine-Borel Theorem, Products of spaces, Tychnoff's Theorem and locally compact spaces, compactness for metric spaces, Lebesgue's covering lemma, Ascoli's Theorem.	15
3	Separation – First and Second countable spaces, Separable spaces, Second countability and Separability, Separation Axioms,T1 spaces and Hausdorff spaces, Completely Regular spaces and Normal spaces, Urysohn's lemma and The Tietze Extension Theorem.	15

4	Connected spaces – connected sets in real line, The components of a space, Totally disconnected spaces, Intermediate value theorem, Locally connected spaces, continuity and connected spaces.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:

1.	Introduction to Topology and Modern Analysis, Tata Mc GrawHill Edition.	G.F. Simmons
2.	Topology	James R. Munkres

Course Title : Complex Analysis **SEM 2**
Course Code : MSMM203CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
To provide the student with the concept and the understanding in Cauchy's theorem, partial fractions and entire functions. Introduce concepts of Sequences, Series of Complex numbers, Power series, Laurent's series, poles and residues, Series of analytic functions and Cachy-Residue theorem, Integrals of rational functions of sin z and cos z, improper integrals.

Course Outcomes:
On completion of the course the students will gain knowledge in concept of functions of complex variable, will learn to evaluate Definite Integrals and Harmonic Functions and understand Residue Calculus.

Unit	Course Content	Instruction Hours
1	Regions in the complex plane, Topology of the complex plane, functions of complex variable, limits, continuity and differentiability, Cauchy-Riemann equations (Cartesian and polar form), sufficient conditions for differentiability, Analytic functions, Harmonic functions, construction of analytic functions, multi-valued functions.	15
2	Complex integrals, definite integral of a complex functions, Contour integral, Cauchy's theorem, extensions of Cauchy's theorem, Cauchy's integral formula and it's generalized form, Morera's theorem, Cauchy's inequality, Liouville's theorem, Maximum modulus principle, minimum modulus principle, Schwartz's lemma.	15
3	Power series, Radius of convergence of power series, Taylor's theorem, Laurent's theorem, zeros and singularities, Residues, Cachy-Residue theorem, Jordan's lemma, Integrals of rational functions of sinz and cosz, improper integrals.	15
4	Conformal mappings, linear transformation, Bilinear transformations, cross ratio, fixed points of bilinear transformation, transformations: $w = \frac{1}{2}\left(z + \frac{1}{z}\right)$, $w = z^2$, exponential, logarithmic and trigonometric transformation.	15

Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References:		
1.	Complex Variables, Prentice Hall	H.S. Kasana
2.	Complex variables and Applications Mc Graw Hill , Seventh Edition, 2004.	James Ward Brown, Ruel V.Churchill
3.	Functions of one Complex Variable, Springer- Verlag.	John B. Conway
4.	Real and Complex Analysis	Walter Rudin

Course Title : Partial Differential Equations (DSE)
Course Code : MSMM204CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
Objectives of the course are to learn to classify the different types of PDE. Topics include initial- and boundary-value problems for parabolic, hyperbolic, and elliptic second-order equations. Emphasis is placed on separation of variables, special functions, transform methods, and numerical techniques

Course Outcomes:
On completion of the course the students will understand the importance of Partial differential equations in science. They will learn to choose an appropriate method for solving PDE and interpreted the qualitative features of solutions.

Unit	Course Content	Instruction Hours
1	Formation of First Order Partial Differential Equations – Solution of linear first order partial differential equations (Lagrange's method) , Integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces , compatibility of first order partial differential equations, Classification of the solutions of first order partial differential equations- solutions of non linear partial differential equations of first order – Charpit's method, Jacobi's method , special types of first order equations, Cauchy's method of Characteristics.	15
2	Second order partial differential equations, origin – linear partial differential equations with constant coefficients, methods of solving linear partial differential equations, classification of second order partial differential equations, Riemann's method.	15
3	Laplace equation and Poisson's equation –Boundary value problems- separation of variables method, Laplace equation in cylindrical and spherical coordinates, interior and exterior Dirichlet problem for a circle, interior Dirichlet problem for a sphere, Miscellaneous examples.	15
4	Solution of Diffusion by separation of variables method, Diffusion equation in cylindrical and Spherical coordinates, D'Alemberts solution of one dimensional Wave equation,	15

	Separation of variable method, two dimensional wave equation, Green's function method of solving Laplace equation, Wave equation and Diffusion equation.	
Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References:		
1.	Elements of Partial Differential equations	I.N.Sneddon
2.	Partial differential equations for engineers and scientists	J.N.Sarma and Kehar.
3.	Partial differential equations	M.D Raisinghania
4.	A first course in Partial Differential equation	E.Weinberger

Course Title : Functional Analysis **SEM 3**
Course Code : MSMM301CCT

Scheme of Instruction

Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination

Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objectives of the course is to develop the theory needed to treat linear integral and differential equations, within the framework of infinite-dimensional linear algebra. Concepts of Normed spaces, Banach spaces, Hilbert spaces with examples are explained. Uniform boundedness principle and the open mapping theorem Banach Contraction Fixed point theorem and its generalization, Schauder's Fixed Point Theorem and applications of fixed point theorems are dealt with in detail.

Course Outcomes:
On completion of the course the students will get a firm understanding of treatment of linear integral and differential equations in higher dimensional spaces and will learn the Fixed point theorems and their applications which are essential for the development of functional analysis.

Unit	Course Content	Instruction Hours
1	Normed and Banach spaces: Definition and examples of normed and Banach spaces. Operators and Functionals, Convex sets, Convex Functionals, Topological properties of normed spaces. Geometric properties of normed spaces.	15
2	Inner product and Hilbert spaces: Basic definitions and properties. Orthogonal complements and projection theorem Reflexivity, Operators in Hilbert spaces. Lax Miligram lemma, projection on convex sets.	15
3	Introduction to fundamental theorem. Hahn Banach Theorem, Principle of Uniform boundedness, Open Mapping and Closed graph theorem.	15
4	Fixed point theorems and their applications. Banach Contraction Fixed point theorem and its generalization, Schauder's Fixed Point Theorem. Application of Fixed Point theorem to Matrix equations, Differential equations, Integral equation.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:

1.	Introduction to Functional Analysis with Application- Anamaya Publishers, 2006.	A.H. Siddiqui, Khalil Ahmad, P. Manchanda
2.	Introduction to Topology and Modern Analysis.	G.F. Simmons.
3.	Functional Analysis	G. Backmenn and Narici.
4.	Functional Analysis	P.K. Jain IP, Ahuja and Khalil Ahmed.
5.	Introductory Functional Analysis with Applications	E. Kreyszig

Course Title : Advanced Algebra **SEM 3**
Course Code : MSMM302CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objectives of this course is to introduce to students advanced topics in Algebra such as Algebraically closed Fields, Galois Theory and applications of Galois Theory to classical problems such as impossibility to find a radical solution to a polynomial of degree five and above, impossibility to square a circle.

Course Outcomes:
On completion of the course the students will be able to appreciate the beauty and power of Algebra. They will learnt how Algebra can be used to find answers to age old problems in mathematics from diverse areas.

Unit	Course Content	Instruction Hours
1	**Algebraic extensions of fields**: Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, Algebraically closed fields.	15
2	**Normal and separable extensions**: Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions.	15
3	**Galois theory** : Automorphism groups and fixed fields, Fundamental theorem of Galois theory , Fundamental theorem of algebra.	15
4	**Applications of Galois theory to classical problems:** Roots of unity and cyclotomic, polynomials, Cyclic extensions, Polynomials solvable by radicals, Symmetric functions, Ruler and compass constructions.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:		
1.	Basic Abstract Algebra.	P.B. Bhattacharya, SK Jain, S R Nagapaul.
2.	Topics in Algebra.	I. N. Herstein
3.	Basic Algebra. published by Hindustan Publishing Company	N.Jacobson
4.	Algebra, Prentice-Hall of India 1991.	M. Artin
5.	Algebra, Vols. I,II & III John Wiley & Sons, 1982, 1989, 1991.	P.M. Cohn
6.	Algebra, 3d edition. Addison-Wesley, 1993	S. Lang,
7.	Linear Algebra, A Geometric Approach. Prentice-Hall of India, 2000.	S. Kumaresan,

Course Title : Fluid Mechanics **SEM 3**
Course Code : MSMM303CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objectives of this course is to teach the basics of Fluid Mechanics, to introduce them to kinematics of fluids, Equation of Continuity, Lagrange's and Euler's equations of motion, Navier-Stroke's equation of motion of Viscous Fluids and its applications.

Course Outcomes:
Fluid Mechanics find applications in a variety of areas such as Physical Sciences, Bio-physics and Space Sciences. On completion of this course the students will be equipped with essential concepts of Fluid Mechanics introducing them to research in applied mathematics.

Unit	Course Content	Instruction Hours
1	Kinematics of Fluids in Motion: Real Fluids and Ideal Fluids. Velocity of a Fluid at a point. Stream Lines and Path Lines. Steady and Unsteady Flows. The Velocity Potential. The Vorticity Vector. Local and Particle Rates of Change. The Equation of Continuity.	15
2	Lagrange's and Euler's equations of motion. Bernoulli's theorem. Equations of motion by flux method. Equations referred to moving axes. Impulsive actions- Stream function. Irrotational motion in two- dimensions.	15
3	The Milne-Thompson Circle Theorem. Some Applications of the Circle theorem. Extension of the Circle theorem. The theorem of Blasius. Viscous Flows: Stress Analysis in Fluid motion. Relation between stress and rate of strain. The Coefficient of Viscosity and Laminar Flow.	15
4	The Navier-Stroke's equation of motion of Viscous Fluids. Some solvable Problems. Steady motion between parallel planes through tube of uniform cross section and flow between concentric rotating cylinders. Steady Viscous Flow in a tube of uniform cross section: A Uniqueness Theorem. Tube having uniform elliptic cross section and equilateral cross section. Diffusion of Vorticity. Energy dissipation due viscosity.	15

Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References :		
1.	Fluid Dynamics -CBS Publications.	Frank Charlton
2.	A Treatise on Hydromechanics: Hydrostatics.	W. H. Besant & A. S. Ramsey.
3.	An Introduction to Fluid Mechanics, Foundation Books- New Delhi, 1994.	G K Batchelor
4.	Fluid Dynamics (With Hydrodynamics), 6^{th} Edn.	M.D. Raisinghania.

Course Title: Classical Mechanics (DSE) **SEM 3**
Course Code: MSMM301DST

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives: Momentum, energy, angular momentum—are central to physics and essential for understanding the Laws of Nature. The main course objectives are to develop familiarity with the physical concepts and develop a mathematical formulism, to develop skills in formulating and solving physics problems. The topics to be covered are the following: Newtonian, Lagrangian and Hamiltonian formulation of classical dynamics. Study the Central-force motion, rigid-body motion, theory of small oscillations and Hamilton-Jacobi theory.

Course Outcomes: On completion of the course the students will get a good foundation in mechanics. They will be trained in Lagrangian and Hamiltonian formulism to solve problems in Classical Mechanics in an elegant way and will have sufficient knowledge to study Quantum Mechanics.

Unit	Course Content	Instruction Hours
1	Mechanics of a particle, Equations of motion in Newtonian formulism. Mechanics of a system of particles. Motion of a system with variable mass. Motion in a Central Force Field. Simple Harmonic Oscillator, Damped Harmonic Oscillator. Elastic & inelastic collisions. Constrains. Generalized coordinates; holonomic & non-holonomic systems.	15
2	Principle of Virtual Work, D'Alembert's principle; Lagrange's equations; Equations of motion of a single particle, system of particles, Harmonic Oscillator in Lagrangian formulism. Cyclic or ignorable coordinates Calculus of Variations. Hamilton's principle, Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-conservative and non-holonomic systems, conservations theorems and symmetry properties.	15
3	Hamilton's equations of motion, conservation theorems and physical significance of Hamiltonian, Hamilton's equations from variational principle, principle of least action. Eulerian angles; Euler's theorem on the motion of a rigid body; infinitesimal rotations; rate of change of a vector; coriolis force; Euler's equations of motion; force free motion of a rigid body; heavy symmetrical top with one point fixed.	15
4	Equations of canonical transformation; integral invariants of Poincare'; Lagrange and Poisson brackets as canonical invariants,	15

	equations of motion in Poisson bracket notation; infinitesimal contact transformations; constants of motion and symmetry properties. The Hamilton-Jacobi equations, Applications.	
Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References:		
1.	Introduction to Classical Mechanics, Tata McGraw Hill, 2004.	Takwale R.G. & Puranik P.S
2.	Classical Mechanics (3d Edition) , Addison Wesley Publications, Massachusetts, 2002.	H. Goldstein
3.	Classical Mechanics-, Orient Longman, London, 1985.	T.W.B. Kibble
4.	Mechanics, Pergamon Press, Oxford, 1976.	L. D. Landau and E.M. Lipshitz,
5.	Lectures on Mechanics, Cambridge University Press, 1992.	J.E. Marsden

Course Title: Celestial Mechanics (DSE) **SEM 3**
Course Code: MSMM302DST

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
Celestial mechanics has played an important role in development of classical mechanics. The three body problem has occupied the centre stage in celestial mechanics for over four hundred years and has very important applications in various planetary theories and satellite dynamics. This course introduces the fundamental framework in which the three body, n-body problem is studied.

Course Outcomes:
On completion of this course students will learn to formulate and solve problems from mechanics in Newtonian, Lagrangian & Hamiltonian formulism. This course would prepare students to take more advanced courses in Classical and Quantum mechanics and will give them an entry in research in space dynamics.

Unit	Course Content	Instruction Hours
1	Coordinate systems. Generalized coordinates. Mechanics of a system of particles. Equation of motion in Newtonian, Lagrangian and Hamiltonian formulism.	15
2	Planetary motion. Kepler's laws. Motion in central force field. Formulation of the two body problem. Integrals of area, angular momentum and energy. Equation of the relative orbit and its solution. Orbit computation by Laplace and Gauss methods.	15
3	Lagrange's solution for the motion of three bodies. Restricted circular three body problem. Jacobi Integral. Surfaces of zero relative velocity. Double points. Stability of straight line and equilateral triangle solutions. Tisserand's Criterion for identification of comets.	15
4	The ten integrals of motion of the n-body problem. Transfer of origin to one of the particles. The perturbing function. Virial theorem. Numerical integration by Cowell's and Encke's methods.	15

Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References:		
1.	Introduction to Classical Mechanics.	R.G.Takwale and P.S.Puranik:
2.	Classical Mechanics	N.C.Rana
3.	Introduction to Celestial Mechanics.	McCusky
4.	Fundamentals of Celestial Mechanics.	Danby

Course Title : Finite Difference Methods (DSE) **SEM 3**
Course Code : MSMM303DST

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objectives of the course are to understand the mathematical and qualitative properties of three basic types of PDE (elliptic, parabolic and hyperbolic equations), to learn the basic principles of Finite Element Method and Finite Difference Method and study its applications.

Course Outcomes:
On completion of the course the students will learn the principles of Finite Element Method and Finite Difference Method and learn to solve PDE using these techniques.

Unit	Course Content	Instruction Hours
1	Partial differential Equations - Introduction - Difference method - Routh Hurwitz criterion - Domain of Dependence of Hyperbolic Equations.	15
2	Difference methods for parabolic partial differential equations - Introduction - One space dimension - two space dimensions - Variable coefficients problems, spherical and cylindrical coordinate System - Non-linear equations with examples.	15
3	Difference methods for Hyperbolic partial differential equations - Introduction - one space dimensions - two space dimensions - First order equations - system of first order equations with examples.	15
4	Numerical methods for elliptic partial differential equations - Introduction Difference methods for linear boundary value problems - General second order linear equation - Equation in polar coordinates - Quasilinear Elliptic equations	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:		
1.	Computational Methods for Partial Differential Equations- Wiley Eastern Limited, New Age International Limited New Delhi.	M.K. Jain, S. R. K. Iyengar, & R. K. Jain
2.	Numerical Solution of Partial Differential Equations: Finite Difference Methods 3rd Edition- Oxford University Press.	G.D. Smith
3.	Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time dependent Problems - Siam	Randall J. Leveque

Course Title : Finite Element Methods (DSE) **SEM 3**
Course Code : MSMM402DST

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objectives of the course are to develop proficiency in the application of the finite element method for modelling, analysis, and interpretation of results. Various important methods and their applications are dealt.
Course Outcomes:
The students learn the essential finite element methods and learn to apply them to a variety of problems from diverse areas.

Unit	Course Content	Instruction Hours
1	Variation principle-Weighted Residual Methods-Least Square Method- Partition Method-Galerkin Method-Moment Method-Collocation Method-Ritz Method.	15
2	Finite Elements-Line Segment Elements-Triangular Element-Rectangular Elements with examples.	15
3	Finite Element Error Analysis-Approximation errors-Variation measures of errors- Convergence of Solution-Accuracy of the solution-Eigen value problems.	15
4	Numerical Integration over finite element: Ritz Finite Element Method-least square Finite Element Method-Galerkin Finite element Method-Assembly of element equations-Application to initial and boundary value problem.	15
Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References:		
1.	Numerical Solution of Differential Equations.	M.K. Jain
2.	Finite Element Method- McGraw-Hill International Edition, Engineering Mechanics Series	J.N. Reddy
3.	Text Book of Finite Element Analysis, Prentice-Hall of India Pvt.Ltd., New Delhi, 2003	P. Seshu
4.	Applied Finite Element Analysis, Second Edition - I.K. International Pvt Ltd.	G. Ramamurty,

Course Title : Graph Theory (DSE) **SEM 3**
Course Code : MSMM401DST

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objectives of this course are to provide an introduction to the language, methods and terminology of the subject and to emphasise on algorithmic and probabilistic approaches that have proved fruitful in modern graph theory.

Course Outcomes:
On completion of the course the students will get familiar with the following notions: graphs; trees; paths; cycles; vertex degree; connectedness; bipartite graphs; complete graphs; subgraphs and the techniques learnt in this course to be useful in other areas of mathematics.

Unit	Course Content	Instruction Hours
1	Graphs, Degree of a vertex, walk, trail, path, cycle, girth circumference, component, cut vertex, cutsets, subgraph spanning and induced subgraph, complement of a graph, self-complementary graph, isomorphism, bridge, regular graph, complete graphs, bipartite graphs.	15
2	Trees, characterisation of trees, branch of a tree, distance in a graph, radius of a graph, diameter of a graph, central vertex, , rank and nullity, fundamental cut-set and circuit, conservation equation, network flow, max-flow min-cut theorem, connectivity, edge-connectivity.	15
3	Eulerian Graphs : path, trial and circuit. Hamiltonian Graphs: path and cycles, line graph, planner graph.	15
4	Directed graphs: Digraphs , binary relations, kinds of digraphs, strong and weak digraphs, condensation of a digraph. Euler digraphs . Applications.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions
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Course Title : Wavelet Analysis and Applications **SEM 4**
Course Code : MSMM401CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives: Wavelet Analysis and Applications is very important course for M. Sc students . The is an introductory course that provides both a systematic exposition of basic ideas and results of wavelet analysis and some applications in statistics, neural networks, differential equations, turbulences, economics and medicine.

Course Outcomes: After go through to this course students can starts research in wavelets and its different applications.

Unit	Course Content	Instruction Hours
1	**Fourier series:** Definition of Fourier series, Fourier series over the interval of length of 2π, Change of interval, Complex form of Fourier series, convergence of Fourier series, Riemann Lebesgue's Lemma, Convergence at a point of continuity, convergence at a point of discontinuity, uniform convergence of Fourier series.	15
2	**Fourier Transform:** Fourier transform in , properties of Fourier transforms Fourier transform in, Parseval's Identities, Change of roof, Inversion formula, Plancherel Theorem, Duality Theorem, Poisson summation formula, Sampling theorem, Heisenberg's uncertainty principle, Heisenberg's inequality, Discrete Fourier transform, Fast Fourier transform.	15
3	**Wavelet Transform:** Wavelet Transform: Gabor transform, Parseval's formula, Inversion formula, Continuous wavelet transform, Mexican hat wavelet, Properties of wavelet transforms, discrete wavelet transform.	15
4	**Multi-resolution Analysis and Construction of Wavelets:** Multi-resolution Analysis, Mother wavelet, Haar wavelet, Shannon wavelet, Meyer wavelet, Orthonormal spline wavelets, Compactly supported wavelets. Applications in Neural Networks, Turbulence and Medicine**.**	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:		
1.	Introduction to Wavelets with Applications- World Education Publishers, 2012	Khalil Ahmad and F. A. Shah:
2.	An Introduction to Wavelet Analysis- Birkhauser , Boston, 2002.	D. F. Walnut
3.	Wavelets: A Tutorial in Theory and Applications- Academic Press, Boston, MA.	C.K. Chui

Course Title : Numerical Methods **SEM 4**
Course Code : MSMM402CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The objectives of this course is to introduce to students various techniques of interpolation, polynomial fitting, finding roots of polynomials, solving integrals and differential equations.

Course Outcomes:
Often in mathematics and physics one deals with data which needs to be analysed, or one needs to solve problems which requires a lot of computations, or there are situations when analytical solutions are hard or impossible to get in such cases one has to resort to numerical solutions. This course

Unit	Course Content	Instruction Hours
1	Representation of integers and fractions, Definition and sources of Error, Definition of Stable problem –Iterative methods – Newton's method –Newton Fourier method –Secant method – Muller's method - Roots of Polynomials – Systems of nonlinear equations – Newton's method for nonlinear systems.	15
2	Polynomial Interpolation theory –Newton divided differences – Finite differences and table oriented Interpolation formulas – Hermite interpolation –the Least square approximation problem – Minimax approximations.	15
3	Numerical Integration- Basic rules of numerical integration, Trapezoidal rule and Simpson's rule, Gaussian rules, composite rules, adaptive quadrature, Extrapolation to the limit, Romberg Integration.	15
4	Solution of Ordinary Differential Equations -Numerical differentiation, difference equations, Taylor series method, Euler's method and its convergence, Runge-Kutta methods, Predicator-Corrector methods, Adams-shooting methods and finite difference methods for Boundary Value Problems.	15

Examination and Evaluation Pattern: Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.		
Text Books and References:		
1.	An Introduction to Numerical Analysis .	Kendall E. Atkinson
2.	Elementary Numerical Analysis - An Algorithmic Approach- 3rd edition ., McGraw Hill, 1981.	Conte S.D. and deBoor C.
3.	Numerical Analysis for Scientists and Engineers .	M.K.Jain–Iyengar - Jain.

Course Title : Calculus of Variations and Integral Equations **SEM 4**
Course Code : MSMM402CCT

Scheme of Instruction
Total Duration : 60 Hr
Periods /Week : 4
Credits : 4
Instruction Mode : Lecture

Scheme of Examination
Maximum Score : 100
Internal Evaluation : 30
End Semester : 70
Exam Duration : 3 Hrs

Course Objectives:
The calculus of variations concerns problems in which one wishes to find the minima or extrema of some quantity over a system that has functional degrees of freedom. It finds applications across pure and applied mathematics and physics. In this course it is shown that such variational problems give rise to a system of differential equations, the Euler-Lagrange equations. Furthermore, the minimizing principle that underlies these equations leads to direct methods for analysing the solutions to these equations.

Course Outcomes:
On completion of the course the students will be able to formulate variational problems and analyse them to deduce key properties of system behaviour.

Unit	Course Content	Instruction Hours
1	Calculus of variations – Functional, Variation of a functional and its properties, Variational problem with fixed boundaries, Extremals, Functional dependent on one unknown function and its first order derivative, Euler's equation, Functional dependent on several unknown functions and their first order derivatives.	15
2	Differential of a function and variation of a functional, Geodesic problem, Variational problems with moving boundaries, Variational problems involving several dependent variables with moving boundaries.	15
3	Linear integral equations – Definition and classification, Conversion of initial and boundary value problems to an integral equation. Eigen values and Eigen functions. Solution of homogeneous and general Fredholm integral equations of second kind with separable kernels.	15
4	Solution of Fredholm and Volterra integral equations of second kind by method of successive substitutions and successive approximations. Resolvent kernel and results related to it. Uniform convergence and uniqueness of series solution.	15

Examination and Evaluation Pattern:
Continuous evaluation through assignments, projects, internal examinations and semester end examination which can contain multiple choice type questions, problem solving and long answer type questions.

Text Books and References:

1.	Calculus of Variations	I. M. Gelfand and S. V. Fomin
2.	Calculus of Variations with Applications	A. S. Gupta
3.	Linear Integral Equations	R. P. Kanwal
4.	Integral Equations and Boundary Value Problems	M. D. Raisinghania

Text Books and References:		
1.	Introduction to theory of graphs. All Allyn and Bacon Inc. Mass(1971).	G. Chartran and M. Behzad.
2.	Graph Theory, Addison-Wesley, reading Mass(1969).	F. Harary.
3.	Introduction to graph theory.	Douglas B. West
4.	Graph Theory with Applications to engineering and computer science.	Narsing Deo

Course Title : Project/DSE
Course Code : MSMM450CCP

Scheme of Instruction		**Scheme of Examination**	
Total Duration	: 60 Hr	Maximum Score	: 100
Periods /Week	: 4	Dissertation	: 70
Credits	: 4	Seminar	: 30
Instruction Mode	: Lecture/Seminar/Library/Field Work		

Objectives:
The objective of allotting projects to students is to expose/train them to do research in mathematics. A suitable area is chosen by the students and his project guide. The student is given the freedom to define his topic of project within the defined area. The students works on the problem defined and through a series of lectures/seminars and library work completes dissertation by the end of the semester and presents his/her results in a seminar.

Outcomes:
The students learn research techniques and research methodology and get a flavour of doing research in mathematics.