M.Sc. - Mathematics

Course Description

Title: AbstractAlgebra-I **Course Code: 21M11MA101**

L-T-P scheme:3-1-0 **Course Credit: 4**

Prerequisite: Students must have basic knowledge of systems of basic algebra.

Objective:

The concept of a group is surely one of the central ideas of Mathematics. The main aim of this course is to introduce Sylow theory and some of its applications to groups of smaller orders. An attempt has been made in this course to strike a balance between the different branches of group theory, abelian groups, nilpotent groups, finite groups, infinite groups and to stress the utility of the subject. Algebra gives to student a good mathematical maturity and enables to build mathematical thinking and skill.

Learning Outcomes:

Course Outcome	**Description**
CO1	Understand concepts of normal subgroup, quotient group, isomorphism, automorphism, conjugacy, G-sets, normal series, composition series, solvable group, nilpotent group and refinement theorem.
CO2	Learn about cyclic decomposition, alternating group An , simplicity of An for n≥5, Sylow's theorem and its applications
CO3	Understand the importance of algebraic properties with regard to working within various number systems.
CO4	Understand concepts of modules, submodules, direct sum, R-homomorphism, quotient module, completely reducible modules, free modules, representation of linear mappings and their ranks
CO5	Learn about similar linear transformation, triangular form, nilpotent transformation
CO6	Think critically by interpreting theorems and apply relating results to problems in other mathematical disciplines

Course Contents:

Unit-I : The class equation, Cauchy`s theorem, Sylow p-subgroups, Direct product of groups

Unit-2 : Application of matrices to the system of linear equations, Consistency of the Structure theorem for finitely generated abelian groups. Normal and subnormal series.

Unit-3: Composition series, Jordan-Holder theorem. Solvable groups. Nilpotent groups..

Unit-4: Field theory — Extension fields. Finite, algebraic, and transcendental extensions. Splitting fields. Simple and normal extensions. Perfect fields..

Unit-5 : Coset decomposition, Lagrange's theorem and its consequences, NormalsubgrPrimitive elements. Algebraically closed fields. Automorphisms of extensions. Galois extensions. Fundamental theorem of Galois theory. Galois group over the rationals.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides ofsubject (will be added from time to time): Digital copy will be available on the JUET server.

Text books:

1. I. N. Herstein, *Topics in Algebra*, Wiley Eastern Ltd, 1975.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, *Basic Abstract Algebra* (2nd Edition), Cambridge University Press, Indian Edition 1997.
3. Ramji Lal, *Algebra,* Vols.1 & 2, Shail Publications, Allahabad 2001.
4. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House 1999.
5. D. S. Malik, J. N. Mordeson, and M. K. Sen, *Fundamentals of Abstract Algebra*, McGraw-Hill International Edition, 1997.
6. Joseph A. Galiian, *Contemporary Abstract Algebra*, Brooks/Cole, Cengage Learning, 2010.

Title : Real Analysis-I | **Course code: 21M11MA102**
L-T-P Scheme: 3 -1 - 0 | **Course Credit: 4**

Prerequisite: Students should have basic knowledge of Calculus.

Objectives: The course aims to familiarize the learner with Riemann-Stieltjes integral, uniform convergence of sequences and series of functions and power series.

Learning Outcomes:

Course Outcome	At the end of the course, the student is able to:
CO1	Understand the concept of Riemann-Stieltjes integral along its properties; integration of vector-valued functions with application to rectifiable curves.
CO2	Know about convergence of sequences and series of functions; construct a continuous nowhere-differentiable function
CO3	Understand differentiability and continuity of functions of several variables and their relation to partial derivatives
CO4	Learn about the concepts of power Series, Abel's theorem, Tauber's theorem, Taylor's theorem, exponential & logarithmic functions, trigonometric functions, Fourier series and Gamma function.
CO5	Demonstrate understanding of the statement and proof of Weierstrass approximation theorem.
CO6	Apply fundamental concepts of real analysis to other fields of science.

Course Contents:

Unit 1: Definition and existence of Riemann-Stieltjes integral, Conditions for R-S integrability. Properties of the R-S integral, Integration anddifferentiation, the fundamental theorem of Calculus, integration of vector-valuedfunctions

Unit 2: Series of arbitrary terms. Convergence, divergence and oscillation, Abel's and Dirichilet's tests. Multiplication of series. Rearrangements of terms of a series, Riemann's theorem.

Unit 3: Sequences and series of functions, pointwise and uniform convergence, Cauchy's criterion for uniform convergence. Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann-Stieltjies integration, uniform convergence and differentiation.

Unit 4: Weierstrass approximation theorem. Power series. Uniqueness theorem for power series, Abel's and Tauber's theorems.

Methodology

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Recommended Books:

1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw-Hill Kgakusha, 1976, International Student Edition.
2. K. Knopp, *Theory and Application of Infinite Series*.
3. T. M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi, 1985.
4. Thomson, B.S., A.M. Bruckner and J.B. Bruckner. Elementary Real Analysis. Prentice Hall, 2001.

Title: Topology **Course Code: 12M11MA301**
L-T-P scheme:3-1-0 **Course Credit: 4**

Prerequisite: Nil

Objective:

To study topological spaces, continuous functions, connectedness, compactness, countability and separation axioms.

Learning Outcomes:

Course Outcome	Description
CO1	Know about topological spaces, understand neighbourhood system of a point and its properties, interior, closure, boundary, limit points of subsets, and base and subbase of topological spaces.
CO2	Understand Open bases and open sub bases, Weak topologies , the function algebras .
CO3	Discuss Tychonoff's theorem, locally compact spaces, Compactness of metric spaces and Ascoli's theorem
CO4	Learn about first and second countable spaces, separable and Lindelof spaces, continuous functions, separation axioms and their properties
CO5	Know about quotient topology; demonstrate understanding of the statements and proofs of Embedding theorem and Urysohn's Lemma
CO6	Know about filters and compactness in topological spaces and apply the knowledge to prove specified theorems

Course Contents:

Unit-1. Definition and examples of topological spaces. Closed sets. Closure. Dense sets. neighborhoods, interior, exterior, and boundary. Accumulation points and derived sets. Bases and sub-bases. Subspaces and relative topology.
Unit-2. Alternative methods of defining a topology in terms of Kuratowski closure operator and neighborhood systems.
Unit-3 Continuous functions and homeomorphism. First and second countable space. Lindelöf spaces. Separable spaces. The separation axioms T_0, T_1, T_2, $T_{3½}$, T_4; their characterizations and basic properties. Urysohn's lemma. Tietze extension theorem.
Unit-4 Compactness. Basic properties of compactness. Compactness and finite intersection property. Sequential, countable, and B-W compactness. Local compactness. One-point compactification.Connected spaces and their basic properties. Connectedness of the real line. Components. Locally connected spaces.
Unit-5 Tychonoff product topology in terms of standard sub-base and its characterizations. Product topology and separation axioms, connected-ness, and compactness (incl. the Tychonoff's theorem), product spaces. Nets and filters, their convergence, and interrelation. Hausdorffness and compactness in terms of net/filter convergence.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides ofsubject (will be added from time to time): Digital copy will be available on the JUET server.

Text books:

1. J. L. Kelley, *General Topology*, Van Nostrand, 1995.
2. K. D. Joshi, *Introduction to General Topology*, Wiley Eastern, 1983.
3. James R. Munkres, *Topology,* 2nd Edition, Pearson International, 2000.
4. J. Dugundji, *Topology*, Prentice-Hall of India, 1966.
5. George F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, 1963.
6. N. Bourbaki, *General Topology,* Part I, Addison-Wesley, 1966.
7. S. Willard, *General Topology,* Addison-Wesley, 1970.
8. S.W. Davis *Topology*, Tata McGraw Hill, 2006

Title of Course: Differential Equations **Course code:** 21M11MA104
L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Students should have basic knowledge of calculus.

Objectives: The aim of the course is to form a strong foundation in the theory of ordinary differential equations and to learn to apply towards problem solving.

Learning Outcomes:

Course Outcome	At the end of the course, the student is able to:
CO1	Understand concepts of an initial value problem and its exact and approximate solutions, existence of solutions, uniqueness of solutions.
CO2	Use Picard's Theoremfor local existence and uniqueness of solutions of an initial value problem.
CO3	Learn about Linear differential equation, Linear dependence and linear independence of solutions. Wronskian theory, Fundamental set. Non-homogeneous LDE.
CO4	Know System of differential equations, Existence theorem for solution of system of differential equations. Dependence of solutions on initial conditions and parameters
CO5	Have deep understanding of theory of Linear second order equations. Sturm theory and related basic theorems. Oscillatory and non-oscillatory equations.
CO6	Model some physical problems and apply knowledge thus earned in other areas of mathematics.

Course Contents:

Unit 1: Existence Theorems for First Order Equations: Initial and Boundary Value Problems, Picard's Iterations, Lipschitz conditions, Sufficient conditions for being Lipschitzian in terms of partial derivatives, Examples of Lipschitzian and Non-Lipschitzian functions, Picard's Theorem for local existence and uniqueness of solutions of an initial value problem of first order which is solved for the derivative, examples of problems without solutions and of equations where Picard's iterations do not converge, Differential equations of first order not solved for the derivative, Uniqueness of solutions with a given slope, Singular solutions, *p*- and *c*-discriminant equations of a differential equation and its family of solutions respectively, Envelopes of one parameter family of curves, singular solutions as envelopes of families of solution curves, Sufficient conditions for existence and nonexistence of singular solutions, examples.

Unit 2: Systems of Differential Equations: Systems of first order equations arising out of equations of higher order, Norm of Euclidean spaces convenient for analysis of systems of equations, Lipschitz condition for functions from R^{n+1} to R^n, Local existence and uniqueness theorems for systems of I order equations, Gronwall's inequality, Global existence and uniqueness theorems for existence of unique solutions over whole of the given interval and over whole of R, Existence theory for equations of higher order, Conditions for transformability of a system of I order equations into an equation of higher order.

Unit 3: Linear systems of first order equations: Linear independence and Wronskians, General solutions covering all solutions for homogeneous and non-homogeneous linear systems, Abel's formula, Method of variation of parameters for particular solutions, Linear systems with constant coefficients, Matrix methods, Different cases involving diagonalizable and non-diagonalizable coefficient matrices, Real solutions of systems with complex eigenvalues.

Unit 4: Linear second order equations—Preliminaries. Basic facts. Theorems of Sturm. Sturm-Liouville Boundary Value Problems. Number of zeros. Nonoscillatory equations and principalsolutions.Nonoscillationtheorems.

Methodology

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Recommended Books:

1. B. Rai, D. P. Choudhury and H. I. Freedman, A Course in Ordinary Differential Equations, Narosa Publishing House, New Delhi, 2002.

2. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall of India, New Delhi, 1968.

3. P.Hartman,OrdinaryDifferentialEquations,John Wiley(1964).

Title : Abstract Algebra-II **Course code: 21M11MA201**
L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Students should have basic knowledge of group and field theory.

Objectives: The course is intended to prepare the students for mathematical theory and methods of linear algebra, in particular vector spaces over the real or complex numbers, linear transformation, diagonalization and orthogonality .

Learning Outcomes:

Course Outcome	At the end of the course, the student is able to:
CO1	Understand the concepts Modules, submodules, Quotient Modules, Homomorphism, linear combination
CO2	Determine Homomorphism decomposition theorem, Isomorphism theorems.
CO3	Understand the concepts Cyclic modules, simple modules and semi-simple modules and rings Schur's lemma
CO4	Use Noetherian and Artinian and rings. Hilbert basis theorem
CO5	Recognizesolution of polynomial equations by radicals. Insolvability of the general equation of degree ≥ 5 by radicals. Finite fields.
CO6	Apply the Jordan blocks and Jordan form to real life problems.

Course Contents:

Unit 1: Modules, submodules, Quotient Modules, Homomorphism, linear combination, direct sums, Product of modules, External sum of family of modules.

Unit 2: Homomorphism decomposition theorem, Isomorphism theorems. Cyclic modules, simple modules and semi-simple modules and rings Schur's lemma.

Unit 3: Free modules. modules Noetherian and Artinian and rings. Hilbert basis theorem.

Unit 4: Solution of polynomial equations by radicals. Insolvability of the general equation of degree greater than 5 by radicals. Finite fields.

Unit-5. Canonical forms: Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a nilpotent transformation. The primary decomposition theorem. Jordan blocks and Jordan form

Methodology

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Learning Resources:

Tutorials and lecture slides of subject (will be added from time to time): Digital copy will be available on the JUET server.

Books:

1. N. Herstain, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. K. Hoffman and R. Kunze, Linear Algebra, Prentice-Hall of India, New Delhi, 1971.
3. N. Jacobson, Basic Algebra, Vols I & II, W.H. Freeman, 1980
4. K.B. Dutta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd, New Delhi, 2000.
5. I.S. Luther and I.B.S. Passi, Algebra, Vol. I - Groups, Narosa Publishing House, Vol. I 1996.

Title: Real Analysis-II **Course code: 21M11MA202**
L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Students should have Good understanding of basic real analysis and topology.

Objectives: The course aims to familiarize the learner with calculus of Functions of several variables, Measure theory and Lebesgue integrals.

Learning Outcomes:

Course Outcome	After completion of course, the students are expected to be able to:
CO1	Generalize concepts previously encountered in one-dimensional analysis to higher dimensions and potential difficulties
CO2	Develop various techniques such as the second derivative tests and Lagrange multiplier methods to find local and global maxima and minima of a multivariable function.
CO3	Understand the fundamental concept of measure and Lebesgue measure.
CO4	Explain the construction of the Lebesgue measure on Euclidean space
CO5	Describe the relationship between continuous functions and general integrable functions
CO6	Apply techniques and theorems of functions of several variables in other areas of mathematics, e.g., optimisation theory, mechanics.

Course Contents:

Unit 1: Functions of several variables. Derivative of functions in an open subset of $\Re^n$ into $\Re^m$ as a linear transformation. Chain rule. Partial derivatives. Taylor's theorem.

Unit 2: Inverse function theorem. Implicit function theorem. Jacobians. extremum problems with constraints, Lagrange's multiplier method, Differentiation of integrals, Partitions of unity, Differential forms.

Unit 3: Measures and outer measures. Measure induced by an outer measure, Extension of a measure. Uniqueness of Extension, Completion of a measure. Lebesgue outer measure. Measurable sets. Non-Lebesgue measurable sets. Regularity. Measurable functions. Borel and Lebesgue measurability.

Unit 4: Integration of non-negative functions. The general integral. Convergence theorems. Riemann and Lebesgue integrals.

Methodology

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Recommended Books:

1. Walter Rudin, *Principle of Mathematical Analysis* (3rd edition) McGraw-Hill Kogakusha, International Student Edition, 1976.
2. H. L., Royden, *Real Analysis*, 4th Edition, Macmillan, 1993.
3. G. de Barra, *Measure Theory and Integration*, Wiley Eastern, 1981.
4. E. Hewitt and K. Stromberg, *Real and Abstract Analysis*, Springer, 1969.
5. P. K. Jain and V. P. Gupta, *Lebesgue Measure and Integration*, New Age International, New Delhi, 2000.
6. R. G. Bartle, *The Elements of Integration*, John Wiley, 1966.
7. I. K. Rana, An Introduction to Measure and Integration, (Second Edition), Narosa Publishing House, New Delhi, 2005.

Title: Advanced Complex Analysis **Course code: 21M11MA203**
L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Students should have basic knowledge of real analysis.

Objectives: The course aims to enable the students to appreciate and critically evaluate the residues, harmonic functions and infinite products

Learning Outcomes:

Course Outcome	This course will enable the students to:
CO1	Understand the essence of complex field
CO2	Know the concepts of differentiation and integration for functions defined over a complex plane in different regions and domains along with the fundamental results.
CO3	Learn various complex variable functions, transformations and series representation of complex functions.
CO4	Understand the concept of singularities, residues, poles and apply the results to solve the improper integrals.
CO5	Demonstrate the conformal mapping and Mobius transformation which have many applicationsin other fields of science and engineering
CO6	Apply various formulae through the relevant theorems which form the base of complex analysis.

Course Contents:

Unit 1: Complex integration. Cauchy—Goursat.Theorem. Cauchy's integral formula. Higher order derivatives.Morera's Theorem. Cauchy's inequality and Liouville's theorem. The fundamental theorem ofalgebra. Taylor's theorem. Maximum modulus principle. Schwarz lemma. Laurent's series. Isolatedsingularities. Meromorphicfunctions. The argument principle. Rouche's theorem Inverse functiontheorem.

Unit 2: Residues. Cauchy's residue theorem. Evaluation of integrals. Branches of many valuedfunctionswithspecialreferencetoargz,logzandz^a.

Unit 3: Bilinear transformations, their properties and classifications. Definitions and examples ofConformalmappings.

Unit 4: Spaces of analyticfunctions. Hurwitz'stheorem. Montel's theorem Riemann mappingtheorem.Weierstrass' factorisationtheorem. Gamma function and its properties. Riemann Zetafunction. Riemann's functional equation. Runge's theorem. Mittag-Leffler's theorem.

Unit 5: AnalyticContinuation. Uniqueness of direct analytic continuation. Uniqueness of analytic continuationalong a curve. Powerseries method of analytic continuationSchwarzReflection principle.Monodromy theorem and its consequences.

Methodology

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Recommended Books:

1. E. C. Titchmarsh, *The Theory of Functions*, Oxford University Press.
2. J. B. Conway, *Functions of One Complex Variable*, Narosa Publishing House, 1980
3. E. T. Copson, *Complex Variables*, Oxford University Press.
4. L. V. Ahlfors, *Complex Analysis*, McGraw-Hill, 1977.
5. D. Sarason, *Complex Function Theory*, Hindustan Book Agency, Delhi, 1994.
6. S.Ponnusamy, Foundation of complex analysis, Narosa publication, 2003.

Title: Advanced Discrete Mathematics **Course Code: 21M11MA204**

Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic principles sets relations functions partially ordered set, lattice, Boolean algebra and its applications. The main objective of the course is to develop in student, an intuitive understanding of graphs by emphasizing on the real world problems.

Learning Outcomes:

At the end of the course, the student is able to:

CO1	Learn the definition of Formal Logic—Statements
CO2	Know Semigroups & Monoids
CO3	Understand Lattices.
CO4	Understand the definition of Boolean Algebra.
CO5	Solve real-life problems using graph theory
CO6	Trees and its applications

Course Contents:

Unit 1: Formal Logic—Statements. Symbolic Representation and Tautologies. Quantifier, Predicates and Validity. Propositional Logic. Semigroups & Monoids-Definitions and Examples of Semigroups and Monoids (including those pertaining to concatenation operation). Homomorphism of semigroups and monoids. Congruence relation and Quotient Semigroups. Subsemigroup and submonoids. Direct products. Basic Homomorphism Theorem.

Unit 2: Lattices—Lattices as partially ordered sets. Their properties. Lattices as Algebraic systems. Sublattices, Direct products, and Homomorphisms. Some Special Lattices e.g., Complete, Complemented and Distributive Lattices.

Unit 3: Boolean Algebras—Boolean Algebras as Lattices. Various Boolean Identities. The Switching Algebra example. Subalgebras, Direct Products and Homomorphisms. Join-irreducible elements, Atoms and Minterms. Boolean Forms and Their Equivalence. Minterm

Boolean Forms, Sum of Products Canonical Forms. Minimization of Boolean Functions. Applications of Boolean Algebra to Switching Theory (using AND, OR & NOT gates). The Karnaugh Map method.

Unit 4: Graph Theory—Definition of (undirected) Graphs, Paths, Circuits, Cycles, & Subgraphs. Induced Subgraphs. Degree of a vertex. Connectivity. Planar Graphs and their properties. Trees. Euler's Formula for connected Planar Graphs. Complete & Complete Bipartite Graphs. Kuratowski's Theorem (statement only) and its use. Spanning Trees, Cut-sets.

Unit 5: Fundamental Cut-sets, and Cycles. Minimal Spanning Trees and Kruskal's Algorithm. Matrix Representations of GraphsEuler's Theorem on the Existence of Eulerian Paths and Circuits. Directed Graphs. Indegree and Outdegree of a Vertex. Weighted undirected Graphs.

Unit 6: Dijkstra's Algorithm.. Strong Connectivity & Warshall's Algorithm. Directed Trees. Search Trees. Tree Traversals. Notions of Syntax Analysis. Polish Notations. Conversion of lnfix Expressions to Polish Notations. The Reverse Polish Notation.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides on ordinary Differential Equations (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw- Hill Book Co., 1997.
2. J.L. Gersting, Mathematical Structures for Computer Science, (3’^ edition), Computer Science Press, New York.
3. Seymour Lepschutz, Finite Mathematics (International edition 1983), McGraw-Hill Book Company, New York.
4. S. Wiitala, Discrete Mathematics—A Unified Approach, McGraw-Hill Book Co.
5. C. L. Liu, Elements of Discrete Mathematics, McGraw-Hill Book Co.
6. N. Deo, Graph Theory with Applications to Engineering and Computer Sciences, Prentice Hall of India.

Title of Course: Mathematical Computing Lab **Course code: 21M17MA201**
L-T-P Scheme: 0 -0 - 4 **Course Credit: 4**

Prerequisite: Students should have basic knowledge of.

Objectives: The course aims to provide fundamental knowledge and practical abilities in MATLAB required to effectively utilizing this tool in technical numerical computations and visualization in other courses.

Learning Outcomes:

Course Outcome	At the end of the course, the student is able to:
CO1	Use Matlab for interactive computations.
CO2	Know syntax of expressions, statements, data types, structures, commands and to write source code for a program.
CO3	Familiar with strings and matrices and their use.
CO4	Generate plots and export this for use in reports and presentations
CO5	Edit, compile/interpret and execute the source program for desired results.
CO6	Use Mathematica/MATLAB for solving various problems of mathematics.

Course Contents:

Unit 1: Introduction to Programming: Components of a computer, Working with numbers

Machine code, Software hierarchy.

Unit 2: Programming Environment: MATLAB Windows, A First Program, Expressions, Constants, Variables and assignment statement, Arrays.

Unit 3: Graph Plots: Basic plotting, Built in functions, Generating waveforms, Sound replay, load and save.

Unit 4: Procedures and Functions: Arguments and return values, M-files, Formatted console input Output, String handling.

Unit 5: Control Statements: Conditional statements: If, Else, Elseif, Repetition statements: While, For; Manipulating Text: Writing to a text file, Reading from a text file, Randomising and sorting a list, Searching a list.

Methodology

Computing lab work will be based on programming in MATLAB for computing various mathematical problems. There will be 12-15 problems/ programmes during the semester.

Evaluation Scheme:

Exams	Marks	Coverage
P-1	15 Marks	**Unit 1-3**
P-2	15 Marks	**Unit 4-5**
Day-to-Day Work	40 Marks	
Lab Record	15 Marks	**70 Marks**
Attendance & Discipline	15 Marks	
Total	**100 Marks**	

Recommended Books:

1. MATLAB Guide, Desmond J. Higham, Nicholas J. Higham, Third Edition, |2016.
2. Beginning MATLAB and Simulink, Novice to Professional, Sulaymon Eshkabilov, 2019.
3. MATLAB & Simulink Student Version Release 14, ISBN 0-9755787-2-3.
4. MATLAB Student Version Release 13, ISBN 0-9672195-9-0.

Title: Functional Analysis **Course Code: 12M11MA402**
L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Nil.

Objectives:

The main objective is to familiarize with normed linear spaces, Banach spaces, inner product spaces and Hilbert spaces. The four fundamental theorems: Hahn-Banach Theorem, Uniform Boundedness Theorem, Open Mapping Theorem and Closed Graph Theorem are the highlights of the course. We also make an excursion into Hilbert spaces, introducing basic concepts and proving the classical theorems associated with the names of Riesz, Bessel and Parseval, along with classifying operators into self-adjoint, unitary and normal operators.

Learning Outcomes:

CO1	Know about the requirements of a norm; completeness with respect to a norm; understand relation between compactness and dimension of a space
CO2	To check boundedness of a linear operator and relate to continuity; convergence of operators by using a suitable norm; apply the knowledge to compute the dual spaces.
CO3	Extend a linear functional under suitable conditions; apply the knowledge to prove Hahn Banach Theorem for further application to bounded linear functionals.
CO4	To know about adjoint of operators; understand reflexivity of a space and demonstrate understanding of the statement and proof of uniform boundedness theorem.
CO5	Understand the strong and weak convergence; understand open mapping theorem, bounded inverse theorem and closed graph theorem; distinguish between Banach spaces and Hilbert spaces; decompose a Hilbert space in terms of orthogonal complements.
CO6	Understand totality of orthonormal sets and sequences; represent a bounded linear functional in terms of inner product; classify operators into self-adjoint, unitary and normal operators.

Course Contents:

Unit 1: Normed linear spaces. Banach spaces and examples. Quotient space of normed linear spaces and its completeness, equivalent norms. Riesz Lemma, basic properties of finite dimensional normed linear spaces and compactness.

Unit 2: Weak convergence and bounded linear transformations, normed linear spaces of bounded linear transformations, dual spaces with examples. Uniform boundedness theorem and some of its consequences.

Unit 3: Open mapping and closed graph theorems. Hahn-Banach theorem for real linear spaces, complex linear spaces and normed linear spaces. Reflexive spaces. Weak Sequential

Compactness. Compact Operators. Solvability of linear equations in Banach spaces. The closed Range Theorem.

Unit 4: Inner product spaces. Hilbert spaces. Orthonormal Sets. Bessel's inequality. Complete orthonormal sets and Parseval's identity. Structure of Hilbert spaces. Projection theorem.

Unit5: Riesz representation theorem. Adjoint of an operator on a Hilbert space. Reflexivity of Hilbert spaces. Self-adjoint operators, Positive, projection, normal and unitary operators. Abstract variational boundary—value problem. The generalized Lax—MiIgram theorem.

Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Learning Resources:

Tutorials and lecture slides of subject (will be added from time to time): Digital copy will be available on the JUET server.

Evaluation plan:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2& Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Text Books:

1. G.F.Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Book Co.,New York, 1983.

2. C.Goffman and G.Pedrick: First Course in Functional Analysis, Prentice Hall of India, New Delhi, 1987.

3. G.Bachman and L.Narici, Functional Analysis, Dover Publications, 2000.

4. L.A.Lustenik and V.J.Sobolev, Elements of Functional Analysis, Hindustan Publishing Corporation, New Delhi, 1971.

5. J.B.Conway: A Course in Functional Analysis, Springer-Verlag, 1990.

6. P.K.Jain, O.P.Ahuja and Khalil Ahmad: Functional Analysis, Second Edition,New Age International(P) Ltd. & Wiley Eastern Ltd., New Delhi, 2010.

Title: Theory of Partial Differential Equations **Course Code: 21M11MA301**
Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic principles partial differential equations, Wave Equation and its applications. The main objective of the course is to develop in student, an intuitive understanding of partial differential equations by emphasizing on the real world problems.

Learning Outcomes:

At the end of the course, the student is able to:

CO1	Employ Initial value Problem in a number of applications to solve numerical problems.
CO2	Appreciate the definition and basics of Heat Equation—Fundamental Solution.
CO3	Visualize the applications Nonlinear First Order PDE.
CO4	Understand the Conservation Laws.
CO5	Solve real-life problems using Wave Equation
CO6	Learn about Hodograph and Legendre Transforms and their applications.

Course Contents:

Unit 1: Transport Equation—Initial value Problem. Non-homogeneous Equation.

Laplace's Equation—Fundamental Solution, Mean Value Formulas, Properties of Harmonic Functions, Green's Function, Energy Methods.

Unit 2: Heat Equation—Fundamental Solution, Mean Value Formula, Properties of Solutions, Energy Methods. Wave Equation—Solution by Spherical Means, Non-homogeneous Equations, Energy Methods.

Unit 3: Nonlinear First Order PDE—Complete Integrals, Envelopes, Characteristics, Hamilton- Jacobi Equations (Calculus of Variations, Hamilton's ODE, Legendre Transform, Hopf-Lax Formula, Weak Solutions, Uniqueness), Conservation Laws (Shocks, Entropy Condtion, Lax- Oleinik formula, Weak Solutions, Uniqueness, Riemann's Problem, Long Time Behaviour)

Unit 4: Representation of Solutions—Separation of Variables, Similarity Solutions (Plane and Travelling Waves, Solitons, Similarity under Scaling), Fourier and Laplace Transform, Hopf-ColeTransform.

Unit 5: Hodograph and Legendre Transforms, Potential Functions, Asymptotics (Singular Perturbations, Laplace's Method, Geometric Optics, Stationary Phase, Homogenization)

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Theory of Partial Differential Equations (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

1. L. C. Evans, *Partial Differential Equations*, Graduate Studies in Mathematics, Vol. 19, AMS, 1999.
2. Jurgen Jost, Partial Differential Equations: Graduate Text in Mathematics, Springer Verlag Heidelberg, 1998.
3. Robert C Mcowen, Partial Differential Equations: Methods and Applications, Pearson Education Inc. 2003.
4. Fritz John, *Partial Differential Equations*, Springer-Verlag, 1986.
5. I.N. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, 1988.

Course Title: Theory of optimization **Course Code:21M11MA302**

L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Nil.

Objectives:

Real life systems can have dozens or hundreds of variables, or more, which may not be handled through standard algebraic techniques. Such systems are used every day in the organization and allocation of resources and are generally handled through linear programming based on "optimization techniques". Linear programming deals with the problems of maximizing or minimizing a linear function subject to linear constraints in the form of equalities or inequalities. The general process for solving linear-programming exercises is to graph the constraints to form a walled-off area called "feasibility region". Then, corners of this feasibility region are tested to find the highest (or lowest) value of the outcome (or resources).

Learning Outcomes:

CO1	Learn background for linear programming, theory of simplex method, detailed development and computational aspects of the simplex method.
CO2	Understand duality and dual simplex method.
CO3	Understand assignment problem and method for solving it.
CO4	Understand transportation model and finding solution of transportation problem.
CO5	Solve Integer programming problems by different methods. Solve nonlinear programming problem by Lagrangian multiplier method.
CO6	Learn about the applications to transportation, assignment in real world.

Course Contents:

Unit-1: Operations Research and its Scope. Necessity of Operations Research in Industry.

Linear Programming-Simplex Method. Theory of the Simplex Method. Duality and Sensitivity Analysis.

Unit-2: Other Algorithms for Linear Programming—Dual Simplex Method. Parametric Linear Programming. Upper Bound Technique. Interior Point Algorithm. Linear Goal Programming. Transportation and Assignment Problems.

Unit-3: Network Analysis—Shortest Path Problem. Minimum Spanning Tree Problem. Maximum Flow Problem. Minimum Cost Flow Problem. Network Simplex Method. Project Planning and Control with PERT-CPM.Dynamic Programming—Deterministic and Probabilistic Dynamic programming..

Unit-4: Game Theory-Two Person, Zero-Sum Games. Games with Mixed Strategies. Graphical Solution. Solution by Linear Programming. Integer Programming—Branch and Bound Technique.

Unit-5: Applications to Industrial Problems—Optimal product mix and activity levels. Petroleum- refinery operations. Blending problems. Economic interpretation of dual linear programming problems. Input-output analysis. Leontief system. Indecomposable and Decomposable economies.Nonlinear Programming—One and Multi-Variable Unconstrained Optimization. Kuhn-Tucker Conditions for Constrained Optimization. Quadratic Programming. Separable Programming. Convex Programming. Non-convex Programming.

Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation plan:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2& Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Text books:

1. Taha, H.A.: Operations Research- An Introduction, New York, Macmillan,1992.
2. Harvey M. Wagner: Principles of Operations Research with Applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd 1975.
3. Hadley, G.: Linear Programming, Massachusetts: Addison- Wesley,1962.
4. Hiller, F.S.and Lieberman G.J.: Introduction to Operations Research, San Francisco: Holden-Day,1995.

Title: Mathematical Methods **Course Code: 12M11MA302**

Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic of differential equations The main objective of the course is to develop in student, an intuitive understanding of Laplace Transform and its applications in various engineering fields.

Course Learning Outcomes:

The course will enable the students to:

CO1	Understand the Fourier Series.
CO2	Learn various techniques of Laplace Transform.
CO3	Know Calculus of Variations.
CO4	Convolution products and application to the Initial Value Problems..
CO5	Solve Euler equations
CO6	Formulate mathematical models in the form Parametric forms

Course Contents:

Unit 1: Fourier Series: Periodic functions, Trigonometric series, Fourier series, Euler formulas, Functions having arbitrary periods, Even and Odd functions, Half-range expansions, Determination of Fourier coefficients without integration, Approximation by trigonometric polynomials, Square error.

Unit 2: Laplace Transform: The Inversion formula, First Shifting Theorem, Laplace Transform of the derivatives and of the Integrals of a function, Derivatives and Integrals of Transforms, Convolution products and application to the Initial Value Problems.

Unit 3: Calculus of Variations: Functionals and extremals, Variation and its properties, Euler equations, Cases of several dependent and independent variables, Functionals dependent on higher derivatives,

Unit 4: Parametric forms, Simple applications. Integral equations of Fredholm and Volterra type, integral equations with degenerate kernels, Fredholm's theorems, eigenvalues and eigen functions of integral equations, Green's function, influence function, Abel integral equation.

Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides on ordinary Differential Equations (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

1. E. Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt. Ltd., 8^{th} Edition, 2001.

2. A. D. Polyanin and A. V. Manzhirov, Handbook of Integral Equations, CRC Press, 2nd Edition, 2008.

3. L. Elsgolts, Differential Equations and Calculus of Variations, Mir Publishers, 1970.

4. A. S. Gupta, Calculus of Variations, Prentice Hall of India, New Delhi, 1999.

5. J. H. Davis, Methods of Applied Mathematics with a MATLAB Overview, Birkhäuser, Inc., Boston, MA, 2004.

6.R. P. Kanwal, Linear Integral Equations, Birkhäuser, Inc., Boston, MA, 1997.

Course Title: Classical Mechanics **Course Code: 21M11MA401**

Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic principles sets relations functions partially ordered set, lattice, Boolean algebra and its applications. The main objective of the course is to develop in student, an intuitive understanding of graphs by emphasizing on the real world problems.

Learning Outcomes:

At the end of the course, the student is able to:

CO1	Learn the definition the Dynamics of a System of Particles
CO2	Understand the Dynamics of Rigid Bodies
CO3	Know Lagrangian Formulation of the Dynamics
CO4	Understand the Theory of small oscillations
CO5	Solve real-life problems using Hamiltonian Formulation of the Dynamics
CO6	Formulate Canonical transformations and its applications

Unit 1: The Dynamics of a System of Particles: The momentum of a system of particles, the linear and the angular momentum, rate of change of momentum and the equations of motion for a system of particles, principles of linear and angular momentum, motion of the center of mass of a system, theorems on the rate of change of angular momentum about different points, with special reference to the center of mass, the kinetic energy of a system of particles in terms of the motion relative to the center of mass of the system. Rigid bodies as systems of particles, general displacement of a rigid body, the displacement of a rigid body about one of its points and the concept of angular velocity, omputation of the angular velocity of a rigid body in terms of the velocities of two particles of the system chosen appropriately, kinematical examples.

Unit 2: The Dynamics of Rigid Bodies: The linear momentum and the angular momentum of a rigid body in terms of inertia constants, kinetic energy of a rigid body, equations of motion, examples on the motion of a sphere on horizontal and on inclined planes.
Unit 3: Euler's equations of motion, motion under no forces, the invariable line and the invariable cone, the theorems of Poinsot and Sylvester, Eulerian angles and the geometrical equations of Euler.

Unit 4 : Lagrangian Formulation of the Dynamics
Generalized co-ordinates, geometrical equations, holonomic and non-holonomic systems, configuration Space, Lagrange's equations using D' Alembert's Principle for a holonomic conservative system, deduction of equation of energy when the geometrical equations do not contain time *t* explicitly, Lagrange's multipliers case, deduction of Euler's dynamical equations from Lagrange's equations.
Theory of small oscillations, Lagrange's method, normal (principal) co-ordinates and the normal modes of oscillation, small oscillations under holonomic constraints, stationary property of normal modes, Lagrange equations for impulsive motion.

Unit 5 : Hamiltonian Formulation of the Dynamics: Generalized momentum and the Hamiltonian for a dynamical system, Hamilton's canonical equations of motion, Hamiltonian as a sum of kinetic and potential energies, phase space and Hamilton's Variational principle, the principle of least action, canonical transformations, Hamilton-Jacobi theory, Integrals of Hamilton's equations and Poisson- Brackets, Poisson-Jacobi identity.

Teaching Methodology:
The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

1. E. A. Milne, Vectorial Mechanics, Methuen & Co. Ltd., London, 1965.
2. A. S. Ramsey, Dynamics, Part II, CBS Publishers & Distributors, Delhi, 1985.
3. H. Goldstein, Classical Mechanics, Addison-Wesley Publishing Company, London, 1969.
4. L. A. Pars, A Treatise on Analytical Dynamics, Heinemann, London, 1968.
5. N. Kumar, Generalized Motion of Rigid Body, Narosa Publishing House, New Delhi, 2004.

Course Title: Advanced Numerical Analysis **Course Code: 21M11MA402**

Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic principles of Numerical Analysis. The main objective of the course is to develop in student, an intuitive understanding of numerical solutions by emphasizing on the real world problems.

Learning Outcomes:

At the end of the course, the student is able to:

CO1	Learn the Integral equations
CO2	Understand the Matrix Computations
CO3	Know numerical solutions of system of simultaneous first order differential equations
CO4	Understand the Numerical solutions of second order boundary value problems
CO5	Solve real-life problems using Finite Element method
CO6	Formulate Rayleigh-Ritz Method and its applications

Unit 1: Integral equations: Fredholm and Volterra equations of first and second types. Conversions of initial and boundary value problems into integral equations, numerical solutions of integral equations using Newton-Cotes, Lagrange`s linear interpolation and Chebyshev polynomial.

Unit 2: Matrix Computations: System of linear equations, Conditioning of Matrices, Matrix inversion method, Matrix factorization, Tridiagonal systems.

Unit 3: Numerical solutions of system of simultaneous first order differential equations and second order initial value problems (IVP) by Euler and Runge-Kutta (IV order) explicit methods.

Unit 4: Numerical solutions of second order boundary value problems (BVP) of first, second and third types by shooting method and finite difference methods.
Unit 5: Finite Element method: Introduction, Methods of approximation: Rayleigh-Ritz Method, Gelarkin Method and its application for solution of BVP.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides on ordinary Differential Equations (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

M. K. Jain, S. R. K. Iyenger and R. K. Jain, Numerical Methods for Scientific and Engineering Computations, New Age Publications, 2003.

M. K. Jain, Numerical Solution of Differential Equations, 2nd edition, Wiley-Eastern.

S. S. Sastry, Introductory Methods of Numerical Analysis,

D.V. Griffiths and I.M. Smith, Numerical Methods for Engineers, Oxford University Press, 1993.

C. F. Gerald and P. O. Wheatley, Applied Numerical Analysis, Addison- Wesley, 1998.

A. S. Gupta, Text Book on Calculas of Variation, Prentice-Hall of India, 2002.

Naveen Kumar, An Elementary Course on Variational Problems in Calculus, Narosa Publishing House, New Delhi, 2004.

Course Title: Differential Geometry **Course Code:21M1GMA101**
Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic Differential Geometry. The main objective of the course is to develop in student, an intuitive understanding of Differential Geometry.

Learning Outcomes:

At the end of the course, the student is able to:

CO1	Explain the basic concepts of tensors
CO2	Understand role of tensors in differential geometry
CO3	Learn various properties of curves including Frenet–Serret formulae and their applications
CO4	Know the Interpretation of the curvature tensor, Geodesic curvature, Gauss and Weingarten formulae
CO5	Understand the role of Gauss's Theorema Egregium and its consequences
CO6	Apply problem-solving with differential geometry to diverse situations in physics, engineering and in other mathematical contexts

Course Contents:

Unit-I: Tensors Contravariant and covariant vectors, Transformation formulae, Tensor product of two vector spaces, Tensor of type (r, s), Symmetric and skew-symmetric properties, Contraction of tensors, Quotient law, Inner product of vectors.

Unit-II: Further Properties of Tensors Fundamental tensors, Associated covariant and contravariant vectors, Inclination of two vectors and orthogonal vectors, Christoffel symbols, Law of transformation of Christoffel symbols, Covariant derivatives of covariant and contravariant vectors, Covariant differentiation of tensors, Curvature tensor, Ricci tensor, Curvature tensor identities.

Unit-III: Curves in $\mathbb{R}$**2** and $\mathbb{R}$**3** Basic definitions and examples, Arc length, Curvature and the Frenet–Serret formulae, Fundamental existence and uniqueness theorem for curves, Non-unit speed curves.

Unit-IV: Surfaces in $\mathbb{R}$**3** Basic definitions and examples, The first fundamental form, Arc length of curves on surfaces, Normal curvature, Geodesic curvature, Gauss and Weingarten formulae, Geodesics, Parallel vector fields along a curve and parallelism.

Unit-V: Geometry of Surfaces The second fundamental form and the Weingarten map; Principal, Gauss and mean curvatures; Isometries of surfaces, Gauss's Theorema Egregium, The fundamental theorem of surfaces, Surfaces of constant Gauss curvature, Exponential map, Gauss lemma, Geodesic coordinates, The Gauss–Bonnet formula and theorem.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides on Theory of Differential Geometry (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

1. Christian Bär (2010). Elementary Differential Geometry. Cambridge University Press.

2. Manfredo P. do Carmo (2016). Differential Geometry of Curves & Surfaces (Revised and updated 2nd edition). Dover Publications.

3. Alferd Gray (2018). Modern Differential Geometry of Curves and Surfaces with Mathematica (4th edition). Chapman & Hall/CRC Press, Taylor & Francis.

4. Richard S. Millman & George D. Parkar (1977). Elements of Differential Geometry. Prentice-Hall.

5. R. S. Mishra (1965). A Course in Tensors with Applications to Riemannian Geometry. Pothishala Pvt. Ltd.

6. Sebastián Montiel & Antonio Ross (2009). Curves and Surfaces. American Mathematical Society.

Title of Course: Mechanics of Fluid **Course code: 21M1GMA201**
L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Students should have basic knowledge of mechanics,vector and tensor analysis.

Objectives:

Learning Outcomes:

Course Outcome	At the end of the course, the student is able to:
CO1	Understand fundamental concepts of fluid mechanics.
CO2	Analyze fluid flow problems with the application of the momentum equation.
CO3	Develop steady and time dependent solutions along with their limitations.
CO4	Use the concept of stress in fluids with applications.
CO5	Find analytical solution of Stoke equation and solutions of some benchmark
CO6	Apply the knowledge in diverse context of modelling.

Course Contents:

Unit 1: Equation of continuity, Boundary surfaces, path lines and streamlines, Irrotational and rotational motions, Vortex lines, Euler's Equation of motion, Bernoulli's theorem, Impulsive actions, Motion in two-dimensions, Conjugate functions, Source, sink, doublets and their images, conformal mapping.
Unit 2: Stress components in real fluid, Equilibrium equation in terms of stress components, Transformation of stress components, Principal stresses, Nature of strains, Transformation of rates of strain, Relationship between stress and rate of strain, Navier-Stokes equation of motion.
Unit 3: Buckingham ∏-theorem, Flow between parallel flat plates, Couette and plane Poiseuille flows, Flow through a pipe, Hagen Poiseuille flow, flow between two co-axially cylinders and two concentric rotating cylinders, Unsteady motion of a flat plate

Unit 4: Two-dimensionalirrotationalmotionproducedbymotionofcircular,co-axialandellipticcylindersinaninfinitemassofliquid.Kineticenergyofliquid.TheoremofBlasius.

Unit 5: Motionofa sphere througha liquid at rest at infinity. Liquid streamingpast a fixed sphere. Equationof motionnofasphere.Stoke'sstreamfunction.

Methodology

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Recommended Books:

1. W.H.BesaintandA.S.Ramsey,ATreatiseonHydromechanics,PartII,CBSPublishers,Delhi ,1988.
2. G.K.Batchelor,AnIntroductiontoFluidMechanics,FoundationBooks,NewDelhi,1994.
3. F.Chorlton,TextbookofFluidDynamics,C.B.S.Publishers,Delhi,1985.
4. A.J.ChorinandA.Marsden,AMathematicalIntroductiontoFluidDynamics,Springer-Verlag,NewYork,1993.
5. L.D.LandauandE.M.Lipschitz,FluidMechanics,PergamonPress,London,1985.
6. R.K.Rathy,AnIntroductiontoFluidDynamics,OxfordandIBHPublishingCompany,New Delhi,1976.
7. A.D.Young,BoundaryLayers,AIAAEducationSeries,WashingtonDC,1989.
8. S.W.Yuan,FoundationsofFluidMechanics,PrenticeHallofIndiaPrivateLimited,NewDelh i,1976.

Course Title: Theory of Linear operators **Code: Code: 21M1GMAXXX**

L-T-P scheme: 3-1-0 **Course Credit: 4**

Prerequisite: Nil

Objective: This course is aimed to introduce about Linear operator theoryto provide the basics regarding the mathematical key features of unboundedoperators to readers that are not familiar with such technical aspects. Itis a necessity to deal with such operators if one wishes to study Quantum mechanics.

Learning Outcomes:

Course Outcome	This course will enable the students to:
CO1	To identify spectrum, point spectrum, approximate point spectrum
CO2	Link the resolvent set of bounded linear operators, learn Spectral mapping theorem for polynomial of operators.
CO3	Explain the significance of the spectral radius of a bounded linear operator.
CO4	To study basics of Banach Algebras, analyse the spectral properties of compact operators on normed spaces
CO5	To study the behaviours of compact operators related to solvability of operator equations
CO6	Learn Fredholm type equations and Fredholm alternatives for integral equations

Course Contents:

Unit-1: Spectral theory in formed linear spaces, resolvent set and spectrum.

Unit-2:Spectral properties of bounded linear operators. Properties of resolvent and spectrum. Spectral mapping theorem for polynomials.

Unit-3:Spectral radius of a bounded linear operator on a complex Banach space. Elementary theory of Banach algebras

Unit-4:General properties of compact linear operators. Spectral properties of compact linear operators on normed spaces.

Unit-5: Behaviors of Compact linear operators with respect to solvability of operators equations. Fredholm type theorems. Fredholm alternative for integral equations.

Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures, assignments and quizzes in the form of questions will also be given for practice.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials, lecture slides and books for this subject will be available on the JUET server.

Recommended Books:

1. E. Kreyszig, Introductory Functional Analysis with applications, John-Wiley & sons, New York, 1978.
2. P.R. Halmo, Introduction to Hilbert Space and the theory of Spectral Multiplicity, 2nd Edition, Chelsea Publishing Co., NY, 1957.
3. N. Dunford and J.T. Schwatz, Linear Operators – 3 parts, Interscience/Wiley, NY, 1958-71.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, NY, 1966.
5. Akhiezer, N.I. and I.M. Glazman, Theory of Linear Operators in Hilbert Spaces, Frederick Ungar Pub. Co. NY, Vol-I (1961), Vol-II (1963).
6. P.R. Halmos, A Hilbert Spaces Problem Book, D. Van Nostrand Co. Inc. 1967.

Course Title: Theory of Probability and Statistics **Course Code: 21M1GMA301**

Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic principles of Probability. The main objective of the course is to develop in student, an intuitive understanding of probability by emphasizing on the real world problems.

Learning Outcomes:

At the end of the course, the student is able to:

CO1	Learn the definition of Probability
CO2	Understand the Special distributions
CO3	Know Statistics
CO4	Understand the Test of Hypotheses
CO5	Solve real-life problems using means, variance, two sample problems
CO6	Formulate SPRT Regression Problem and its applications

Unit 1: Probability: - Axiomatic definition, Properties. Conditional probability, Bayes rule and independence of events. Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function, Chebyshev's inequality.

Unit 2: Special distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Hyper geometric, Poisson, Uniform, Exponential, Gamma, Normal joint distributions, Marginal and conditional distributions, Moments, dependence of random variables, Covariance, Correlation. Functions of random variables. Weak law of large numbers, P. Levy's central limit theorem (finite variance case), Normal and Poisson approximations to binomial.

Unit 3: Statistics: - Population, Sample, Parameters. Point Estimation: Method of moments, MLE, Unbiasedness, Consistency, Comparing two estimators (Relative MSE). Confidence interval estimation for means, difference of means, variance, proportions, Sample size problem.

Unit 4: Test of Hypotheses:-N-P Lemma, Examples of MP and UMP tests, p-value, Likelihood ratio test, Tests for means, variance, two sample problems, Test for proportions, Relation between confidence intervals and tests of hypotheses, Chi-square goodness of fit tests, Contingency tables,

Unit 5: SPRT Regression Problem:- Scatter diagram, Simple linear regression, Least squares estimation, Tests for slope and correlation, Prediction problem, Graphical residual analysis, Q-Q plot to test for normality of residuals, Multiple regression, Analysis of Variance: Completely randomized design and randomized block design, Quality Control: Stewart control charts and Cusum charts.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

(1) R. Murray, Probability and Statistics.

(2) Frederich Mosteller, Probability and Statistics.

(3) S. C. Gupta and V. K . Kapur, Probability and Statistics.

(4) T. Veerarajan ,Probability, Statistics and Random Processes, Tata McGraw Hill.

(5) J.J. Aunon & V. Chandrasekhar, Introduction to Probability and Random Processes, Mc-Graw Hill International Ed.

(6) A. Papoulis & S.U. Pillai, Probability, Random Varibles and Stochastic Processes, Mc-Graw Hill.

Course Title: Fuzzy sets and their applications **Course Code: 21M1GMA401**

Credits: 3+1+0 **Course Credit: 4**

Prerequisite: Nil

Objectives:

The aim of the course is to cover the basic principles of Fuzzy Sets. The main objective of the course is to develop in student, an intuitive understanding of Fuzzy Sets by emphasizing on the real world problems.

Learning Outcomes:

At the end of the course, the student is able to:

CO1	Learn the definition of Basic Concepts of Fuzzy Sets
CO2	Understand Fuzzy Relations
CO3	Know Fuzzy Arithmetic
CO4	Understand the Fuzzy Logic
CO5	Solve real-life problems using Baye's theorem
CO6	Formulate Fuzzy Implications and Approximate Reasoning and its applications

Unit 1: Basic Concepts of Fuzzy Sets: Motivation, Fuzzy sets and their representations, Membership functions and their designing, Types of Fuzzy sets, Operations on fuzzy sets, Convex fuzzy sets. Alpha-level cuts, Zadeh's extension principle, Geometric interpretation of fuzzy sets.

Unit 2: Fuzzy Relations: Fuzzy relations, Projections and cylindrical extensions, Fuzzy equivalence relations, Fuzzy compatibility relations, Fuzzy ordering relations, Composition of fuzzy relations. Fuzzy Arithmetic: Fuzzy numbers. Arithmetic operations on fuzzy numbers.

Unit 3: Fuzzy Logic: Fuzzy propositions, Fuzzy quantifiers, Linguistic variables, Fuzzy inference, Possibility Theory: Fuzzy measures, Possibility theory, Fuzzy sets and possibility theory, Possibility theory versus probability theory.

Unit 4: Probability of a fuzzy event. Baye's theorem for fuzzy events. Probabilistic interpretation of fuzzy sets. Fuzzy mapping rules and fuzzy implication rules. Fuzzy rule-based models for function approximation. Types of fuzzy rule-based models (the Mamdani, TSK, and standard additive models).

Unit 5: Fuzzy Implications and Approximate Reasoning: Decision making in Fuzzy environment: Fuzzy Decisions, Fuzzy Linear programming, Fuzzy Multi criteria analysis, Multi-objective decision making. Fuzzy databases and queries: Introduction, Fuzzy relational databases, Fuzzy queries in crisp databases.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 & Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	100 Marks	

Learning Resources:

Tutorials and lecture slides (will be added from time to time): Digital copy will be available on the JUET server.

Recommended Books:

1. J. Yen and R. Langari: *Fuzzy Logic: Intelligence, Control, and Information,* Pearson Education*, 2003.*

2. G. J. Klir and B. Yuan: *Fuzzy Sets and Fuzzy Logic: Theory and Applications,* Prentice-Hall of India, *1997.*

3. H.J. Zimmermann, *Fuzzy Set theory and its Applications*, Kluwer Academic Publ, 2001.

Course Title: Information theory **Code: 21M1GMAXXX**

L-T-P scheme:3-1-0 **Credit: 4**

Prerequisite: Nil.

Objective:

This course contains systematic study of coding and communication of messages. This course is concerned with devising efficient encoding and decoding procedures using modern algebraic techniques. The course begins with basic results of error detection and error correction of codes, thereafter codes defined by generator and parity check matrices are given.

Learning Outcomes:

Course Outcome	**Description**
CO1	To learn the basis of information, information measure, types of entropies.
CO2	Understand group codes, matrix encoding techniques, polynomial codes and Hamming codes
CO3	Understand the joint and conditional entropies and communication channel.
CO4	Have deep understanding of finite fields, BCH codes
CO5	Learn about linear codes, cyclic codes, self dual binary cyclic codes
CO6	Learn about MDS codes, Hadamard matrices and Hadamard codes

Course Contents:

Unit-1: Measure of Information—Axioms for a measure of uncertainity. The Shannon entropy and its properties. Joint and conditional entropies. Transformation and its properties.Noiseless coding—Ingredients of noiseless coding problem. Uniquely decipherable codes. Necessary and sufficient condition for the existence of instantaneous codes. Construction of optimal codes.

Unit-2: Discrete Memoryless Channel—Classification of channels. Information processed by a channel. Calculation of channel capacity. Decoding schemes. The ideal observer. The fundamental theorem of Information theory and its strong and weak converses.

Continuous Channels—The time-discrete Gaussian channel. Uncertainty of an absolutely continuous random variable. The converse to the coding theorem for lime-discrete Gaussian channel. The time-continuous Gaussian channel. Band-limited channels.

Unit-3: Some imuitive properties of a measure of entropy—Symmetry, normalization, expansibility, boundedness, recursivity maximality, stability, additivity, subadditivity, nonnegativity, continuity, branching etc. and interconnections among them. Axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

Unit-4: Information functions, the fundamental equation of information, information functions continuous at the origin, nonnegative bounded information functions, measurable information functions and entropy. Axiomatic characterizations of the Shannon entropy due to Tverberg and Leo. The general solution of the fundamental equation of information. Derivations and their role in the study of information functions.

Unit-5: The branching property. Some characterizations of the Shannon entropy based upon the branching property. Entropies with the sum property. The Shannon inequality. Subadditive, additive entropies.TheRenji entropies. Entropies and mean values. Average entropies and their equality, optimal coding and the Renji entropies. Characterization of some measures of average code length.

Teaching Methodology:

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	**Marks**	**Coverage**
Test-1	15 Marks	Based on Unit-1
Test-2	25 Marks	Based on Unit-2 & Unit-3 and around 30% from coverage of Test-1
Test-3	35 Marks	Based on Unit-4 to Unit-5 and around 30% from coverage of Test-2
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	
Total	**100 Marks**	

Learning Resources:

Tutorials and lecture slides of this subject (will be added from time to time): Digital copy will be available on the JUET server.

Text books:

1. R.Ash,InformationTheory,IntersciencePublishers,NewYork,1965.
2. F.M.Reza,AnintroductiontoInformationTheory,MacGraw-HillBookCompanyInc.,1961.
3. J.AczelandZ.Daroczy,Onmeasuresofinformationandtheircharacterizations,Academic Press,NewYork.
4. Introduction to Information Theory and Coding, Probability, Entropy, Channels, and Error Detection and Correction Codes, Heba Al-Asady, 2019.

Title of Course: Wavelet Analysis **Course code: 21M1GMAXXX**
L-T-P Scheme: 3 -1 - 0 **Course Credit: 4**

Prerequisite: Students need to know Laplace and Fourier transforms.

Objectives: To learn about concepts of wavelet functions and wavelet transforms that are used in solving ordinary and partial differential equations, data compression, denoising, signal and image processing.

Learning Outcomes:

Course Outcome	At the end of the course, the student is able to:
CO1	Understand the problem of approximation of functions in various spaces, Fourier series.
CO2	Learn concept of wavelet functions, Haar spaces, design of wavelets and filter banks
CO3	Know the basics of continuous and discrete wavelet transforms, wavelet base.
CO4	UnderstandMultiresolution Analysis, Mother wavelets; construction of scaling function with compact support, splines and the continuous wavelet transform.
CO5	Learn the applications of wavelets in the construction of orthonormal bases by wavelets.
CO6	Aply wavelets to the real-world problems.

Course Contents:

Unit 1: Fourier Analysis: Fourier and inverse Fourier transforms, Convolution and delta function, Fourier transform of Square integrable functions. Fourier series, Poisson's Summation formula.
Unit 2: Wavelet Transforms and Time Frequency Analysis: The Gabor Transform. Short-time Fourier transforms and the uncertainity principle. The integral wavelet transforms Dyadic wavelets and inversions. Frames. Wavelet Series.
Unit 3: Scaling Functions and Wavelets: Multi resolution analysis, scaling functions with finite two scale relations. Direct sum decomposition of $L^2(R)$. Linear phase filtering, Compactly supported wavelets,
Unit 4: Wavelets and their duals, Orthogonal Wavelets and Wavelet packets, Example of orthogonal Wavelets. Identification of orthogonal two-scale symbols, Construction of Compactly supported orthogonal wavelets, Orthogonal wavelet packets, orthogonal decomposition of wavelet series.

Methodology

The course will be covered through lectures supported by tutorials. Apart from the discussions on the topics covered in the lectures assignments/ quizzes in the form of questions will also be given.

Evaluation Scheme:

Exams	Marks	Coverage
Test-1	15 Marks	Syllabus covered upto Test-1
Test-2	25 Marks	Syllabus covered upto Test-2
Test-3	35 Marks	Full Syllabus
Assignment	10 Marks	
Tutorials	5 Marks	
Quiz	5 Marks	
Attendance	5 Marks	

Recommended Books:

1. C.K.Chui, A First Course in Wavelets, Academic press NY 1996.
2. I. Daubechies, Ten Lectures in Wavelets, Society for Industrial and Applied Maths, 1992.
3. A Wavelet Tour of Signal Processing, Third Edition: The Sparse Way, by S. Mallat, 2009.
4. Akansu, Ali N.; Haddad, Richard A, Multiresolution Signal Decomposition: Transforms, Subbands, and Wavelets, Boston, MA: Academic Press, ISBN 978-0-12-047141-6, 1992.