1st Semester		Contact Hrs.			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MMAT1-101	Abstract Algebra	4	0	0	40	60	100	4
MMAT1-102	Real Analysis	4	0	0	40	60	100	4
MMAT1-103	Mechanics	4	0	0	40	60	100	4
MMAT1-104	Differential Equation	4	0	0	40	60	100	4
MCAP0-193	Fundamentals of Computer & C Programming	4	0	0	40	60	100	4
MCAP0-194	Fundamentals of Computer & C Programming Lab	0	0	2	100	0	100	1
Total	**Theory = 5 Labs = 1**	**20**	**0**	**2**	**300**	**300**	**600**	**21**

2nd Semester		Contact Hrs.			Marks			Credits
Subject	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MMAT1-205	Advance Algebra	4	0	0	40	60	100	4
MMAT1-206	Measure Theory and Integration	4	0	0	40	60	100	4
MMAT1-207	Complex Analysis	4	0	0	40	60	100	4
MMAT1-208	Tensors & Differential Geometry	4	0	0	40	60	100	4
MMAT1-209	Numerical Analysis	4	0	0	40	60	100	4
MMAT1-210	Numerical Analysis Lab	0	0	2	100	0	100	1
Total	**Theory = 5 Labs = 1**	**20**	**0**	**2**	**300**	**300**	**600**	**21**

3rd Semester		Contact Hrs.			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MMAT1-311	Topology	4	0	0	40	60	100	4
MMAT1-312	Operations Research	4	0	0	40	60	100	4
MMAT1-313	Mathematical Statistics	4	0	0	40	60	100	4
MMAT1-314	Mathematical Methods	4	0	0	40	60	100	4
MMAT1-315	Seminar-I	0	0	2	100	0	100	1
Departmental Elective - I (Select any one)		4	0	0	40	60	100	4
MMAT1-356	Fourier Analysis & Applications							
MMAT1-357	Advanced Numerical Analysis							
Open Elective – I	**(Select any one)**	3	0	0	40	60	100	3
Total	**Theory = 6 Labs =Nil**	**23**	**0**	**2**	**340**	**360**	**700**	**24**

4th Semester		Contact Hrs.			Marks			Credits
Subject Code	**Subject Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
MMAT1-416	Number Theory	4	0	0	40	60	100	4
MMAT1-417	Functional Analysis	4	0	0	40	60	100	4
MMAT1-418	Partial Differential Equations	4	0	0	40	60	100	4
MMAT1-419	Seminar-II	0	0	2	100	0	100	1
Departmental Elective–II (Select any one)		4	0	0	40	60	100	4
MMAT1-458	Advanced Operation Research							
MMAT1-459	Advanced Complex analysis							
MMAT1-460	Fractional Calculus							
Departmental Elective–III (Select any one)		4	0	0	40	60	100	4
MMAT1-461	Graph Theory							
MMAT1-462	Sampling Distribution and Estimation Theory							
MMAT1-463	Fuzzy Set Theory and Application							
Open Elective-II (Select any one)		3	0	0	40	60	100	3
Total	**Theory = 6 Labs =Nil**	**23**	**0**	**2**	**240**	**360**	**700**	**24**

Overall

Semester	Marks	Credits
1st	600	21
2nd	600	21
3rd	700	24
4th	700	24
Total	**2600**	**90**

QUESTION PAPER PATTERN
END SEMESTER EXAMINATION

Time Allowed: 3 Hrs. **Maximum Marks: 60**

The question paper shall consist of three sections.

1. Section A is compulsory. It carries 16 marks. It consists of 4 questions of 4 marks each. One question should be set from each unit.
2. Section B consist of 4 questions of 08 marks each with atleast 1 question from each unit. The student has to attempt any 3 questions out of it.
3. Section C consist of 3 questions of 10 marks each. The student has to attempt any 2 questions.

ABSTRACT ALGEBRA

Subject Code: MMAT1-101 **L T P C** **Contact Hrs.: 45**
4 0 0 4

Course Objectives

To Introduce the Concepts and to Develop Working Knowledge On Class Equation, Solvability of Groups, Composition Series, Ideals, Factorization Domain.

Course Outcomes

Students will be able to assess properties implied by the definitions of groups and Rings. Analyze & demonstrate examples of subgroups, normal subgroups, quotient groups, ideals, quotient rings. Use the concepts of isomorphism and homomorphism for groups and rings.

UNIT-I (13 Hrs.)

Group Theory: Groups, Subgroups, Normal subgroups, Quotient groups, Homomorphism, Automorphism, Cyclic groups, Permutation groups, Conjugate elements and conjugacy classes, Class equation of a finite group and its applications, Sylow's theorems, Direct products, Normalizer and centralizer.

UNIT-II (10 Hrs.)

Composition Series: Normal and sub normal series, Composition series, Zassenhaus's lemma, Scherer's refinement theorem and Jordan-holder theorem, Derived group, Solvable groups, Fundamental theorem of arithmetic.

UNIT-III (10 Hrs.)

Ring Theory: Rings, Subrings, Quotient rings, Ideals, Maximal ideals, Prime ideals, Nilpotent and nil ideals, Field of quotients of an integral domain.

UNIT-IV (12 Hrs.)

Factorization Domain: Factorization theory in integral domains, Divisibility, Rings of Gaussian integers, Unique Factorization domains, Polynomial rings over unique factorization domains, Principal ideal domain (PID), Euclidian domain(ED) and their relationships.

Recommended Books:

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, 'Basic Abstract Algebra', Cambridge University Press, **1997.**
2. I.N. Herstein, 'Topics in Algebra', 2nd Edn., Wiley Eastern, **1975.**
3. Surjeet Singh, Quzai Zameeruddin, 'Modern Algebra', Vikas Publishing House, New Delhi.
4. David S. Dummit, 'Abstract Algebra', 2nd Edn., Pearson, **2010.**
5. Joseph A. Gallian, 'Contemporary Abstract Algebra', 4th Edn., Narosa, **2008**.
6. Artin Michael, 'Algebra', 2nd Edn., Pearson, **2010.**

REAL ANALYSIS

Subject Code: MMAT1-102 **L T P C** **Contact Hrs.: 45**
4 0 0 4

Course Objectives

To work comfortably with completeness of R, convergence of sequence in metric space, uniform continuity in metric space, Riemann - Stieltjes integration.

Course Outcomes

To Determine the Riemann integrability & Riemann-Stieltjes integrability of a bounded function & Recognize the difference between Countable and uncountable sets, Open and closed sets. Also illustrate the effect of Continuity with compactness, connectedness.

UNIT-I (12 Hrs.)

Set Theory: Bounded sets, Superimum and infimum, the completeness property of R, the Archimedean property, Finite, Countable and uncountable sets, Equivalent sets, Metric spaces, Open and closed sets, Compact sets, Elementary properties of compact sets, K-cells, Compactness of k-cells, Compact subsets of Euclidean space R^k. Perfect sets, Cantor set, Separated sets, connected sets, Connected subsets of real line.

UNIT-II (10 Hrs.)

Convergence in Metric Space: Convergent Sequences (In Metric Spaces), Cauchy Sequences, Subsequences, Complete Metric Space, Cantor's Intersection Theorem, Category of A Set and Baire's Category Theorem, Banach Contraction Principle.

UNIT-III (12 Hrs.)

Continuity in Metric Space: Limits of functions (in metric spaces), Continuous functions, Continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions, Uniform continuity.

UNIT-IV (11 Hrs.)

Riemann Stieltjes Integral: Riemann stieltjes integral: definition and existence of integral, Properties of integral, Integration and differentiation, Fundamental theorem of calculus, First and second mean value theorems for riemann stieltjes integral.

Recommended Books

1. Apostol, 'Mathematical Analysis', Addition –Wesley.
2. R.G. Bartle and D.R. Sherbert, 'Introduction to Real Analysis', 3rd Edn., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, **2002**.
3. W. Rudin, 'Principles of Mathematical Analysis', 3rd Edn., McGraw Hill, Kogakusha, **1976**.
4. G.F. Simmons, 'Introduction to Topology and Modern Analysis', McGraw Hill Ltd., **2008.**
5. G.B. Folland, 'Real Analysis', 2nd Edn., John Wiley, New York, **1999.**
6. H.L. Royden, 'Real Analysis', Macmillan, New York, **1988.**

MECHANICS

Subject Code: MMAT1-103 | **L T P C 4 0 0 4** | **Contact Hrs.: 45**

Course Objectives

To study mechanical systems under generalized coordinate systems, Virtual work, Energy and momentum, to study mechanics developed by Lagrange, Hamilton, Jacobi and small oscillation**.**

Course Outcomes

On successful completion of the course, students will be able to use of the Lagrange's equation for deriving equation of motions and apply the knowledge in Dynamics at higher levels.

UNIT-I (10 Hrs.)

Lagrangian Mechanics: Generalized coordinates, Holonomic and non-holonomic systems, Scleronomic and rhenomic systems, Generalized potential, Lagrange's equations of motion of first kind and second kind, Energy equation for conservative field.

UNIT-II (12 Hrs.)

Hamiltonian Mechanics: Hamilton variables, Hamilton canonical equation, Cyclic coordinates, Canonical transformations, Hamilton's principle, Principle of least action, Whittaker's equations, Donkin's theorem.

UNIT-III (12 Hrs.)

Small Oscillations for Conservative System: Small oscillations of conservative system, Lagrange's equation for small oscillations, Nature of roots of frequency equation, Principle oscillations. Normal coordinates Hamilton- Jacobi equation and Jacobi theorem.

UNIT-IV (11 Hrs.)

Poisson Brackets and Lagrange Bracket: Poisson brackets, Poisson's identity, Jacobi - Poisson theorem, Lagrange bracket, Condition of canonical character of transformation in terms of Lagrange bracket and Poisson brackets. Poincare- carton integral invariant, invariance of Lagrange bracket and Poisson brackets under canonical transformation.

Recommended Books

1. F. Gantmacher, 'Lectures in Analytic Mechanics', Mir Publisher, Moscow, **1975.**
2. H. Goldstien, C. Ppoole and J.L. Sofco, 'Classical Mechanics', 3rd Edn., Addison Wesely, **2002**.
3. L.D. Landau and E.M. Lipshitz, 'Mechanics', Pergamon Press, Oxford, **1976**.
4. J.E. Marsden, 'Lectures on Mechanics', Cambridge University Press, **1992.**

DIFFERENTIAL EQUATION

Subject Code: MMAT1-104	**L T P C** **4 0 0 4**	**Contact Hrs.: 45**

Course Objectives

To introduce the theoretical concepts of ordinary and partial differential equations.

Course Outcomes

Ability to apply differential equations to significant applied and theoretical problems.
Investigate the qualitative behavior of solutions of systems of differential equations and interpret in the context of an underlying model.

UNIT-1 (13 Hrs.)

Existence of Differential Equation

Existence and uniqueness and continuation of solutions of a differential equation and system of differential equation

Boundary Value Problems

Boundary value problems for second order differential equations, Green's function and its applications, Eigen value problems, Self adjoint form, Sturm-liouville problem and its applications.

UNIT-II (10 Hrs.)

Stability Theory: Autonomous system, Phase plane and its phenomenon, Critical points and stability for linear and non-linear systems, Liapunov's direct method, Periodic solutions, limit cycle, Poincare-Bendixson Theorem.

UNIT-III (12 Hrs.)

First Order Partial Differential Equation: First order pde: partial differential equations, origins and classification of first order PDE, Initial value problem for quasi-linear first order equations: existence and uniqueness of solutions, Non-existence and non-uniqueness of solutions, Surfaces orthogonal to a given system of surfaces, Non-linear PDE of first order, Cauchy method of characteristics, Compatible systems of first order equations, Charpit's method, Solutions satisfying given conditions, Jacobi's method.

UNIT-IV (9 Hrs.)

Second Order Partial Differential Equation

Second order PDE: the origin of second order pde, Equations with variable coefficients, classification and canonical forms of second order equations in two variables, Classification of second order equations in *n* variables.

Recommended Books

1. M. Braun, 'Differential Equations and Their Applications', 4th Edn., Springer, **2011.**
2. F. Braue and J.A. Nohel, 'The Qualitative Theory of Ordinary Differential Equations', Dover Publications, **1989.**
3. E.A. Coddington, 'Ordinary Differential Equations', Tata McGraw Hill, **2002.**
4. G.F. Simmons, 'Differential Equations with Applications and Historical Notes', 2nd Edn., Tata McGraw Hill, **2003.**
5. W.E. Boyce and R.C. Diprima, 'Elementary Differential Equations and Boundary Value Problems'.
6. E.C. Zachmanoglou, D.W. Thoe, 'Introduction to Partial Differential Equations with

Applications', Dover Publications, **1986.**
7. I.N. Sneddon, 'Elements of Partial Differential Equations', McGraw Hill Book Company, **1988.**
8. T. Amarnath, 'An Elementary Course in Partial Differential Equations', 2nd Edn., Narosa Publishing House, **2012.**

FUNDAMENTALS OF COMPUTER AND C PROGRAMMING

Subject Code: MCAP0-193 **L T P C** **Contact Hrs.: 45**
4 0 0 4

Course Objectives
1. The intention is for the student to be able to articulate and demonstrate a basic understanding of the fundamental concepts of information technology and office tools.
2. The objective of this course is to help the students in finding solutions to various real life problems and converting the solutions into computer program using C language (structured programming).

Course Outcomes
1. Ability to implement programs using C.
2. Ability to implement fundamental data structures in C.

UNIT-I (8 Hrs.)

Computer Fundamentals: Block diagram of a computer, Characteristics of computers, Hardware- input devices, Output devices, Memories, Software, System software, Application software, Compiler, Interpreter, utility program, Introduction to operating Systems-Windows based/MACOS/LINUX, Significance and advantages of operating systems.

UNIT-II (8 Hrs.)

C programming: Introduction to C language, Evolution and characteristics of C language, Character set, Keywords, Identifiers, Data types, Variables, Constants, Operators, Expressions, Type conversion and type casting, Overview of pre-processors, Structure of a C program, Input and output statements.

Control Statements:
Basic programming constructs, 'if', 'if-else', 'nested-if' statements, Conditional operator, 'for', 'while', 'do - while', Switch, Break, Continue.

UNIT-III (11 Hrs.)

Arrays and strings
Need for an array, Declaration and initialization, Basic operation on arrays, Multi-dimensional array, Structures, Union, Introduction to strings, String handling.

Pointers
Introduction, Declaration and initialization, Pointers and arrays: Similarities and advantages/disadvantages of using pointers. Introduction to structures and unions.

UNIT-IV (11 Hrs.)

Functions and Storage Classes
Need for functions, Prototype, Function definition, Function call, return type and return statement, Passing arguments, Functions and arrays, Functions and pointers, Recursive functions, Difference between recursion and iteration storage classes.

Files
Introduction, File Operations, Character I/O, String I/O, Numeric I/O, Formatted I/O, Block I/O.

Recommended Books
1. Shubhnandan Jamwal, 'Programming in C', 3rd Edn., Pearson.
2. E. Balagurusamy, 'Programming in ANSI C', 3rd Edn., Tata McGraw Hill.
3. V. Rajaraman, 'Fundamentals of Computers', 3rd Edn., PHI.

4. P.K Sinha, ‘Computer Fundamental’, 5th Edn., BPB Publication.
5. Brian Kernighan and Dennis Ritchie, ‘C Programming Language’, 2nd Edn., PHI.
6. Byron Gottfried, ‘Programming with C’, 2nd Edn., Tata McGraw Hill.
7. Yashvant P. Kanetkar, ‘Let us C’, 4th Edn., BPB Publications, New Delhi.
8. R.S. Salaria, ‘Application Programming in C’, Edn’, Khanna Book Publishing.

FUNDAMENTALS OF COMPUTER AND C PROGRAMMING LAB.

Subject Code: MCAP0-194 **L T P C 0 0 2 1** **Contact Hrs.: 60**

Course objectives

1. The intention is for the student to be able to articulate and demonstrate a basic understanding of the fundamental concepts of information technology and office tools.
2. The objective of this course is to help the students in finding solutions to various real life problems and converting the solutions into computer program using C language (structured programming

Course Outcomes

1. Ability to implement programs using C.
2. Ability to implement fundamental data structures in C.

WORD PROCESSING & PRESENTATION TOOL

Salient features of word, Installation of word, Starting and quitting of word, File, Edit, View, Insert, Format, Tools, Tables, Window, Help options and all of their features, Options and sub options etc. Transfer of files between word processors and software packages.
Salient features of power point, Installation, Starting and quitting, File, Edit, View, Insert, Format, Tools, Slide Show, Window, Help options and all of their features, Options and Sub Options etc. Transfer of files between presentation tool and software packages.

SPREAD SHEET TOOL

Spread sheet. Getting started with excel worksheet, entering data into Work sheet, editing cell addressing, Ranges and range names, Commands, Menus, Copying and Moving cell contents, Inserting and deleting rows and columns, Column width control, Cell protection, Printing reports, Creating and displaying graphs, Statistical functions.

C Programming

1. **Operators:** Arithmetic, Logical, Conditional, Assignment, Increment/Decrement operators
2. **Decision Making**: switch, if-else, nested if, else-if ladder, break, continue, go to
3. **Loops**: while, do-while, for
4. **Functions:** Definition, Declaration, call by value, Call by reference, Recursive Function
5. **Arrays:** Arrays declarations, Single and multi-dimensional, Strings and string functions
6. **Pointers:** Pointer declarations, Pointer to function, Pointer to array.

Recommended Books

1. Shubhnandan Jamwal, ‘Programming in C’, 3rd Edn., Pearson.
2. E. Balagurusamy, ‘Programming inANSI C’, 3rd Edn., Tata McGraw Hill.
3. V. Rajaraman, ‘Fundamentals of Computers’, 3rd Edn., PHI.
4. P.K. Sinha, ‘Computer Fundamentals’, 5th Edn.’, BPB Publication.
5. Brian Kernighan and Dennis Ritchie, ‘C Programming Language, 2nd Edn., PHI.
6. Byron Gottfried, ‘Programming with C’, 2nd Edn., Tata McGraw Hill.
7. Yashvant P. Kanetkar, ‘Let us C’, 4th Edn., BPB Publications, New Delhi.
8. R.S. Salaria, ‘Application Programming in C’, 2nd Edn., Khanna Book Publishing.

ADVANCE ALGEBRA

Subject Code: MMAT1-205 **L T P C** **Contact Hrs.: 45**
4 0 0 4

Course objectives

To study field extension, Roots of polynomials, Galois theory, Finite fields, Orthonormal basis and inner product space.

Course Outcomes

To demonstrate the idea of a ring, field and an integral domain and be able to prove the basic results of ring theory and field extensions, unique factorization in rings and integral domains.

UNIT-I (11 Hrs.)

Inner Product Space: Dual of a vector space, Dual basis, Reflexivity, Annihilators, Inner product spaces, Orthogonal and ortho-normal basis, Gram Schmidt ortho-normalization Process.

UNIT-II (12 Hrs.)

Field Extension: Finite, Algebraic and Transcendental extensions, Irreducible polynomials. Gauss lemma, Eisenstein's criterion, Kronecker's theorem, Algebraic extensions, algebraically closed fields.

UNIT-III (12 Hrs.)

Finite Field: Splitting fields, Normal extensions, Multiple roots, Finite fields, Separable extensions, Perfect fields, Primitive elements, Lagrange's theorem on primitive elements.

UNIT-IV (10 Hrs.)

Galois Theory: Galois extensions, Galois group of an extension and fundamental theorem of Galois theory.

Recommended Books

1. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, ‘Basic Abstract Algebra’, Cambridge University Press, **1997.**
2. I.N. Herstein, ‘Topics in Algebra’, 2^{nd} Edn., Wiley Eastern, **1975.**
3. Surjeet Singh, Quzai Zameeruddin, ‘Modern Algebra’, 8^{th} Edn., Vikas Publishing House, New Delhi, **2006**.
4 David S. Dummit, ‘Abstract Algebra’, 2^{nd} Edn., Pearson, **2010.**
5 A. Gallian Joseph, ‘Contemporary Abstract Algebra’, 4^{th} Edn., Narosa, **2008**.
6 Artin Michael, ‘Algebra’, 2^{nd} Edn., Pearson, **2010.**

MEASURE THEORY AND INTEGRATION

Subject Code: MMAT1-206 **L T P C** **Contact Hrs.: 45**
4 0 0 4

Course Objectives

To introduce measure on the real line, Lebesgue measurability, Integrability, Differentiability, Functions of bounded variation and Completeness of L^p Space.

Course Outcomes

1. Ability to implement the idea of Lebesgue Measure of Sets and Functions.
2. Ability to implement Lebesgue Integration and Lebesgue Differentiation, Fatou’s Lemma & Theory on L^p-Space.

UNIT-I (12 Hrs.)

Lebesgue Measure of Sets and Functions: Lebesgue measure, Measurable sets, Regularity, Non-measurable sets, Measurable functions, Borel and lebesgue measurability, Littlewood’s three principles.

UNIT-II (11 Hrs.)

Lebesgue Integration: The lebesgue integral of a simple function and bounded function, Comparison of Riemann and lebesgue integral, Bounded convergence theorem, Integral of non - negative functions, Fatou's Lemma, Monotone convergence theorem, The general lebesgue integral, Lebesgue convergence theorem, Integration of series.

UNIT-III (12 Hrs.)

Lebesgue Differentiation: Vitali's lemma, the four Dini derivate, Continuous non differentiable functions, Functions of bounded variation, Lebesgue differentiation theorem, Differentiation and integration, the lebesgue set.

UNIT-IV (10 Hrs.)

Theory on L^p-Space: Convex functions, Jensen's inequality, L^p-spaces, Holder's and Minkowski's inequalities. Convergence in mean, Completeness of L^p, Approximation in L^p spaces.

Recommended Books

1. G.de Bara, 'Measure Theory and Integration', Ellis Horwood Limited, England, **2003**.
2. G.B. Folland, 'Real Analysis', 2nd Edn., John Wiley, New York, **1999.**
3. E. Kreyszig, 'Introductory Functional Analysis with Applications', John Wiley, **1989.**
4. H.L. Royden, 'Real Analysis', Macmillan, New York, **1988.**
5. P.K. Jain and V.P. Gupta, 'Lebesgue Measure and Integration', 2nd Edn.

COMPLEX ANALYSIS

Subject Code: MMAT1-207 **L T P C** **4 0 0 4** **Contact Hrs.: 45**

Course Objectives

To Study Cauchy integral formula, Local properties of analytic functions, General form of Cauchy's theorem and evaluation of definite integral and harmonic functions.

Course Outcomes

To Apply the concept and consequences of analyticity and the Cauchy-Riemann equations and evaluate contour integrals directly by the fundamental theorem. Represent functions as Taylor, power and Laurent series, classify singularities and poles & find residues.

UNIT-I (11 Hrs.)

Theory of Analytic Function: Function of complex variable, Continuity and differentiability, Analytic functions, Conjugate function, Harmonic function, Cauchy Riemann equation (Cartesian and polar form), Construction of analytic functions, Stereographic projection and the spherical representation of the extended complex plane.

UNIT-II (10 Hrs.)

Complex Integration: Complex line integral, Cauchy's theorem, Cauchy's integral formula and its generalized form, Cauchy's inequality, Poisson's integral formula, Morera's theorem, Liouville's theorem.

UNIT-III (12 Hrs.)

Singularities: Power series, Taylor's theorem, Laurent's theorem, Zero's, Singularities, Residue at a pole and at infinity, Cauchy's residue theorem, Jordan's lemma, Integration round unit circle, Evaluation of improper integrals, Fundamental theorem of algebra and Rouche's theorem, Maximum modulus principle, Schwarz lemma.

UNIT-IV (12 Hrs.)

Bilinear Transformation: Conformal transformation, Bilinear transformation, Critical points, Fixed points, Problems on cross-ratio and bilinear transformation.

Recommended Books

1. L.V. Ahlfors, 'Complex Analysis', 2nd Edn., McGraw Hill International Student Edition, **1990.**

2. E.T. Capson, 'An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, **1995.**
3. R. Churchill, J.W. Brown, 'Complex Variables and Applications', 6th Edn., New York, McGraw Hill, **1996.**
4. A.R. Shastri, 'An Introduction to Complex Analysis', Macmillan India Ltd., **2003**.
5. S. Ponnusamy, 'Foundation of Complex Analysis', Narosa Book Distributors, **2011.**

TENSORS AND DIFFERENTIAL GEOMETRY

Subject Code: MMAT1-208 | **L T P C 4 0 0 4** | **Contact Hrs.: 45**

Course Objectives

The course aims to introduce vector algebra and vector calculus and introduces space curves and their intrinsic properties of a surface and geodesics. Further the non-intrinsic properties of surfaces are explored.

Course Outcomes

To explain the concepts of differential geometry and its role in modern Mathematics,
Apply differential geometry techniques to specific research problems in Mathematics to solve tensor analysis as well.

UNIT-I (10 Hrs.)

Tensors Analysis: Systems of different orders, Summation convention, Kronecker symbols, Transformation of coordinates in Sn, Invariants, Covariant and contravariant vectors, Tensors of second order, Mixed tensors, Zero tensor, Tensor field, Algebra of tensors, Equality of tensors, Symmetric and skew – symmetric tensors, Outer multiplication, Contraction and inner multiplication, Quotient law of tensors, Reciprocal tensor of tensor, Relative tensor, Cross product of vectors.

UNIT-II (10 Hrs.)

Reimannian Tensor and Christoffel Symbols: Riemannian space, Christoffel symbols and their properties, Covariant differentiation of tensors, Riemannian christoffel curvature tensor, Intrinsic differentiation.

UNIT-III (13 Hrs.)

Introduction to Differential Geometry: A simple arc, Curves and their parametric representations, Arc length, Tangent, Principal normal, Bi- normal, Serret-Frenet formula, Curvature and torsion, Definition of a surface, Curves on a surface, Two fundamental forms, Helicoids, Metric, Direction coefficients, Families of curves, Isometric correspondence, Intrinsic properties.

UNIT-IV (12 Hrs.)

Geodesics: Geodesics, Differential equation of geodesics, Canonical geodesic equations, Normal property of geodesics, Existence theorems, Geodesics curvature, Gauss - Bonnet theorem, Gaussian curvature.

Recommended Books

1. S. Kobayashi and K. Nomizu, 'Foundations of Differential Geometry', Interscience Publishers, **1963.**
2. D.T. Struik, 'Lectures on Classical Differential Geometry', Addison - Wesley, Mass, **1950.**
3. J.L. Synge and Schild A., 'Tensor Calculus', Toronto, **1949.**
4. Ahsan Zafar, 'Tensors, Mathematics of Differential Geometry and Relativity', EEE, PHI, **2015**.
5. Weather Burn Ce, 'An Introduction to Riemannian Geometry and the Tensor Calculus', CUP, **1938**.

NUMERICAL ANALYSIS

Subject Code: MMAT1-209	L T P C 4 0 0 4	Contact Hrs.: 45

Course Objectives

Construction and use of numerical systems, Influence of data representation and computer architectures on algorithms choice and development, use numerical methods for solving a problem, locate and use good mathematical software, get the accuracy you need from the computer, assess the reliability of the numerical results, and determine the effect of round off error or loss of significance.

Course Outcomes

To analyze the error incumbent in any such numerical approximation, Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, interpolation and approximation, numerical differentiation and integration.

UNIT-I (10 Hrs.)

Introduction to Number System & Methods to Find Roots of Polynomials: Number system, Error in evaluating a function, Absolute, Relative, Truncation and round off errors, Floating point arithmetic, Bounds on error, Error propagation in computation. Algebraic and transcendental equations: Bisection method, Iteration method, Regula-falsi method, Secant method, Newton-Raphson method. Convergence of these methods, Methods for multiple roots: Newton Raphson method, Muller's method, Solution of Non-linear simultaneous equations: Fixed point iteration method, Seidel method and Newton Raphson method.

UNIT-II (10 Hrs.)

Methods to Solve System of Linear Equations: System of linear algebraic equations: Guass elimination method, Gauss – Jordon method, LU factorization method, Jacobi and Gauss-Seidal methods, Convergence of iteration methods, Round-off errors and refinement, ill-conditioning, Partitioning method, Inverse of matrices. Eigen values and Eigen vectors: Rayleigh power method, Given’s method and House –Holder method.

UNIT-III (13 Hrs.)

Interpolation, Numerical Differentiation and Integration: Interpolation: Finite differences, Newton Gregory forward and Backward formula, Lagrange's formulae with error, Divided differences, Newton's formulae, Central differences, Hermite interpolation. Numerical differentiation and integration: Differentiation at tabulated and non-tabulated points, Maximum and minimum values of tabulated function, Newton-Cotes Formulae-Trapezoidal, Simpson’s, Boole’s and Weddle’s rules of integration, Romberg integration, Gaussian integration, Double integration by Trapezoidal and Simpson rules.

UNIT-IV (12 Hrs.)

Methods to Solve Ordinary Differential Equation: Ordinary differential equations: Taylor series and Picard’s methods, Euler and modified Euler methods, Runge–Kutta methods, Predictor- Corrector methods: Adams-Bashforth and Milne methods, Error analysis and accuracy of these methods, Solution of simultaneous and higher order equations, Boundary values problems: Finite difference and shooting methods

Recommended Books

1. B. Bradie, ‘A Friendly Introduction to Numerical Analysis’, Pearson Prentice Hall, **2006.**
2. K.E. Atkinson, ‘Introduction to Numerical Analysis’, 2nd Edn., John Wiley, **1989.**
3. S.D. Conte and C. De Boor, ‘Elementary Numerical Analysis: An Algorithmic Approach’, 3rd Edn., McGraw Hill, New York, **1980.**
4. J.B. Scarborough, ‘Numerical Mathematical Analysis’, Oxford & IBH Publishing Co., **2001.**

NUMERICAL ANALYSIS LAB.

Subject Code: MMAT1-210 **L T P C**
0 0 2 1

Course Outcomes

1. Solve numerically algebraic equations, linear systems of equations, ordinary and partial differential equations, eigenvalue problems & Carry out numerical differentiation, integration and interpolation.
2. Develop understanding of numerical error and applicability of a particular method.

The following programs of following methods are to be practiced:

1. To find a real root of an algebraic/ transcendental equation by using Bisection method.
2. To find a real root of an algebraic/ transcendental equation by using Regula-Falsi method.
3. To find a real root of an algebraic/ transcendental equation by using Newton-Raphson method.
4. To find a real root of an algebraic/ transcendental equation by using Iteration method.
5. Implementation of Gauss- Elimination method to solve a system of linear algebraic equations.
6. Implementation of Gauss Jordan method to solve a system of linear algebraic equations.
7. Implementation of Gauss-Seidel method to solve a system of linear algebraic equations.
8. Implementation of Newton's Forward interpolation formula to find tabulated values.
9. Implementation of LaGrange's interpolation formula to find tabulated values.
10. Implementation of Newton's Divided Difference formula to find tabulated values.
11. To evaluate double integrals by using Trapezoidal and Simpson method.
12. To compute the solution of ordinary differential equations by using Euler's method.
13. To compute the solution of ordinary differential equations by using Runge -Kutta methods.
14. To find differential equation using Picards method.
15. To compute the solution of ordinary differential equations by using Milne-Simpson method.

Recommended Books

1. E. Balagurusamy, 'Object Oriented Programming with C++', Tata McGraw Hill, New Delhi, **1999.**
2. J.N. Sharma, 'Numerical Methods for Engineers and Scientists', 2nd Edn., Narosa Publishing House, New Delhi/ Alpha Science International Ltd. Oxford UK, **2007.**
3. Conte and de Boor, 'Numerical Analysis', McGraw Hill, New York, **1990.**
4. John H. Mathews, 'Numerical Methods for Mathematics, Science and Engineering', 2nd Edn., Prentice Hall, New Delhi, **2000.**

TOPOLOGY

Subject Code: MMAT1-311 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives

To provide the basic knowledge of topological properties such as connectedness, compactness, separation axioms and metrization theorem.

Course Outcomes

To illustrate the concept of topological spaces and continuous functions, product topology and quotient topology. Also define connectedness and compactness, and prove a selection of related theorems, and Describe different examples distinguishing general, geometric and algebraic topology.

UNIT-I (12 Hrs.)

Cardinal numbers and their arithmetic, Cantor's theorem and the continuum hypothesis, Zorn's Lemma, Well-ordering theorem, Topological spaces: Definition and examples, Euclidean spaces as topological spaces, Basis for a given topology, Sub-basis, Equivalent basis, Elementary concepts: Closure, Interior, Frontier and Dense sets, Tautologizing with pre-assigned elementary operations, Relativization, Subspaces.

UNIT-II (11 Hrs.)

Continuous functions, Characterization of continuity, Open maps and Closed maps, Homeomorphisms and embedding, Cartesian product topology, Elementary concepts in product spaces, Continuity of maps in product spaces and slices in Cartesian products.

UNIT-III (11 Hrs.)

Connected spaces, Connected subspaces of the real line, Components and path components, Local connectedness, Compact spaces, Sequentially compact spaces, Heine-Borel theorem, compact subspaces of the real line, Local-compactness and one-point compactification.

UNIT-IV (11 Hrs.)

Countability Axioms: Separable spaces, Lindelo-f spaces, Separation axioms: T_0, T_1 and T_2 spaces, Regular space, Completely regular and Normal spaces, Urysohn lemma, Urysohn metrization theorem, Tietze extension theorem, Tychnoff theorem.

Recommended Books:

1. J.R. Munkres, 'Topology- A First Course', Prentice Hall of India, New Delhi, **1975**.
2. James Dugundji, 'Topology', Allyn and Bacon, Boston, **1966**.
3. K.D. Joshi, 'Introduction to General Topology', Wiley Eastern, Delhi, **1986**.
4. S. Kumaresan, 'Topology of Metric Spaces', 2nd Edn., Narosa Publishing House, New Delhi, **2015**.

OPERATIONS RESEARCH

Subject Code: MMAT1-312	**L T P C** **4 0 0 4**	**Contact Hrs.-45**

Course Objectives

To acquaint the students with the theory and techniques of Operations Research.

Course Outcomes

Formulate and model a linear programming problem from a word problem and solve them graphically in 2 and 3 dimensions, while employing some convex analysis. Find the dual identify and interpret the solution of the Dual Problem.

UNIT –I (13 Hrs.)

Introduction, Definition of operation research, Models in operation research. Formulation of linear programming problem (LPP): Graphical method, Basic Feasible Solution, optimal solution of LPP using Simplex, Big-M and Two phase methods, Exceptional cases in LPP i.e. Infeasible, unbounded, alternate and degenerate solutions, Extreme Points, Convex set, Convex linear combination.

UNIT –II (10 Hrs.)

Duality in Linear Programming: General Primal-Dual pair, formulating a dual problem, duality theorems, Complementary slackness theorem, Duality & simplex method, Dual simplex method, Sensitivity analysis: change in right hand side of constraints, change in the objective function and coefficient matrix addition and deletion of constraint and variables.

UNIT III (11 Hrs.)

Transportation Problem: Initial basic Feasible solution, Balanced and unbalanced transportation problems, Optimal solutions of transportation problem using U-V/MODI methods, Assignment problems: Mathematical formulation of assignment problem, typical assignment problem, the traveling salesman problem, Test for optimality, degeneracy, Project management with critical path method.

UNIT –IV (11 Hrs.)

Concept of convexity and concavity, Maxima and minima of convex functions, Single and multivariate unconstrained problems, constrained programming problems, Kuhn-Tucker conditions for constrained programming problems, Quadratic programming, Wolfe's method.

Recommended Books:

1. H.A. Taha, 'Operations Research-An Introduction', PHI, **2007**.
2. Kanti Swarup, P.K. Gupta and Man Mohan, 'Operations Research', 9^{th} Edn., Sultan Chand & Sons, **2002**.
3. Friderick S. Hillier and Gerald J. Lieberman, 'Operations Research', 2^{nd} Edn., Holden-Day Inc, USA, **1974.**
4. M.S. Bazaraa, H.D. Sherali, C.M. Shetty, 'Nonlinear Programming: Theory and Algorithms', John Wiley and Sons, **1993**.
5. S. Chandra, Jayadeva, A. Mehra, 'Numerical Optimization and Applications', Narosa Publishing House, **2013**.

MATHEMATICAL STATISTICS

Subject Code: MMAT1-313 **L T P C** **4 0 0 4** **Contact Hrs.: 45**

Course Objectives

To introduce the concept of random variables, distribution functions, various probability distributions, and concepts in testing of statistical hypotheses.

Course Outcomes

To understand the concept of probability theory and statistics to solve industrial problems. Define and examine the random sampling and graphical methods with technology. Recognize and compute the sampling distributions, sampling distributions of means and variances (S2) and the t- and F-distributions, Recognize the relationship between the confidence interval estimation and tests of hypothesis.

UNIT-I (12 Hrs.)

Concept of random variables and probability distributions: Two dimensional random variables, Joint, Marginal and conditional distributions, Independence of random variables, Expectation, Conditional expectation, Moments, Product moments, Probability generating functions, Moment generating function and its properties, Moment inequalities, Techebyshey's, inequalities, Characteristic function and its elementary properties.

UNIT-II (13 Hrs.)

Study of various discrete and continuous distributions: Binomial, Poison, Negative binomial, Geometric, Hyper geometric, Rectangular, Normal, Exponential, Beta and gamma distributions.

UNIT–III (8 Hrs.)

Concept of sampling distribution and its standard error, Derivation of sampling distributions of Chi-square, t and F (null case only) distribution of sample mean and sample variance and their in random sampling from a normal distribution.

UNIT–IV (12 Hrs.)

Elementary concepts in testing of statistical hypotheses, Tests of significance: tests based on normal distribution, Chi-square, t and F statistic and transformation of correlation coefficient, tests for regression coefficients and partial and multiple correlation coefficients.

Analysis of variance: One-way classification, two-way classification with one observation per cell.

Recommended Books:

1. R.V. Hogg & Craige, 'Introduction to Mathematical Statistics', 7^{th} Edn., **2005.**

2. J.W. Mckean and A.T. Craig, P. Mukhopadhyay, 'Mathematical Statistics', **2000.**
3. S.C. Gupta, V.K. Kapoor, 'Fundamental of Mathematical Statistics', 7th Edn., S. Chand, **1990**.
4. Goon, Gupta and Das Gupta, 'Fundamentals of Statistics', 5th Edn., World Press, **1975**.
5. V.K. Rohatgi, 'Introduction to Probability Theory & Mathematical Statistics', **2009**.

MATHEMATICAL METHODS

Subject Code: MMAT1-314 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives
To introduce the concept of linear integral equations and their solutions, Different types of variational problems.
Course Outcomes
To solve linear Volterra and Fredholm integral equations using appropriate methods and also understand the relationship between integral and differential equations.

UNIT–I (11 Hrs.)

Linear integral equations of first and second kind, Abel's problem, Relation between linear differential equation and Volterra's equation, Nonlinear and Singular equations, Solution by successive substitutions, Volterra's equation, Iterated and reciprocal functions, Volterra's solution of Fredholm's equation.

UNIT-II (11 Hrs.)

Fredholm's equation as limit of finite system of linear equations, Hadamard's theorem, Convergence proof, Fredholm's two fundamental relations, Fredholm's solution of integral equation when $D(\lambda)\neq 0$, Fredholm's solution of dirichet's problem and neumann's problem, Lemmas on iterations of symmetric kernel, Schwarz's inequality and its applications.

UNIT-III (12 Hrs.)

Simple variational problems, Necessary condition for an extremum, Euler's equation, End point problem, Variational derivative, Invariance of Euler's equation, Fixed end point problem for n-unknown functions, Variational problem in parametric form, Functional depending on higher order derivatives.

UNIT–IV (11 Hrs.)

Euler -Lagrange equation, First integral of Euler-Lagrange equation, Geodesics, The Brachistochrone, Minimum surface of revolution, Brachistochrone from a given curve to a fixed point, Snell's law, Fermat's principle and calculus of variations.

Recommended Books:
1. F.B. Hildebrand, 'Method of Applied Mathematics', 1st Edn., Prentice Hall, India, **1952**.
2. I.M. Gelfand & S.V. Fomin, 'Calculus of Variations', 1st Edn., Prentice Hall, India, **1963**.
3. W.W. Lovitt, 'Linear Integral Equations', 2nd Edn., Dover, India, **2005.**
4. Robert Weinstock, 'Calculus of Variations', 1st Edn., Dover, **1975.**
5. M.D. Raisinghania, 'Integral Equations and Boundary Value Problems', 6th Edn., S. Chand, **2015.**

SEMINAR-I

Subject Code: MMAT1-315 **L T P C**
0 0 2 1

1. Each of these Courses of Seminar will consist of 100 marks (internal only) having L T P C as 0 0 2 1.
2. In the beginning of the semester, a teacher will be allocated maximum 30 students. The latter will guide/teach them how to prepare/present 15 minutes Power Point Presentation for the Seminar.

3. If there are more than 30 students in the class, then class will be divided into two groups having equal students. Each group may be allocated to a different teacher.
4. Each student will be allotted a topic by the teacher at least one week in advance for the presentation. The topic for presentation may be from the syllabus or relevant to the syllabus of the programme.
5. During the presentation being given by a student, all the other students of his/her group will attend the Seminar. The assessment/evaluation will be done by the teacher. However, Head of Department and other faculty members may also attend the Seminar, ask questions and give their suggestions.
6. This is a turn wise continuous process during the semester and a student will give minimum two presentations in a Semester.
7. For the evaluation, the following criteria will be adopted,
   a) Attendance in Seminar: 25 Marks
   b) Knowledge of Subject along with Q/A handling during the Seminar: 25 Marks
   c) Presentation and Communication Skills: 25 Marks
   d) Contents of the Presentation: 25 Marks.

FOURIER ANALYSIS & APPLICATIONS

Subject Code: MMAT1-356 **L T P C** **Contact Hrs.: 45**
4 0 0 4

Course Objectives

To provide the knowledge and concepts of Fourier series, its convergence and uniform convergence, Fourier transforms and its applications for the solution of differential equations.

Course Outcomes

To understand the concept of Fourier series, Dirichlet's conditions, Convergence and Uniform convergence of Fourier series. Define Fourier transforms, Application of Fourier transforms and Discrete Fourier Transform.

UNIT-I (8 Hrs.)

Fourier Series: Fourier series, Theorems, Dirichlet's conditions, Fourier series for even and odd functions, Half range Fourier series, Other forms of Fourier series.

UNIT-II (10 Hrs.)

Convergence and Uniform convergence of Fourier series, Cesaro and Abel Summability of Fourier series, The Dirichlet Kernal, The Fejer kernel, L^2-theory: Orthogonality, Completeness.

UNIT-III (15 Hrs.)

Fourier Transforms: Dirichlet's conditions, Fourier integral formula (without proof), Fourier transform, Inverse Theorem for Fourier transform, Fourier sine and cosine transforms and their inversion formulae. Properties of Fourier transform, Convolution theorem of Fourier transforms, Parseval's identity, Finite Fourier sine and cosine transform, Inversion formula for sine transform,

Application of Fourier Transforms: Simultaneous ordinary differential equations, second order Partial differential equations (Heat, Wave and Laplace).

UNIT-IV (12 Hrs.)

The Discrete Fourier Transform (DFT): Definition, Theorems, Properties: Periodic and Linear Convolution by DFT, The Fast Fourier Transform, FFT convolutions, Two dimensional FFT Analysis.

Recommended Books:

1. Javier Duoandikoetxe, 'Fourier Analysis', University Press, **2012**.
2. Gerald B. Folland, 'Fourier Analysis and its Applications', American Mathematical Society, **2010**.

3. N.K. Bary, ‘A Treatise on Trigonometric Series’ Vol. 1, Pergamon, **2014**.
4. B.S. Grewal, ‘Higher Engineering Mathematics’, Khanna Publisher, **2014**.
5. Duraisamy Sundararajan, ‘The Discrete Fourier Transform: Theory, Algorithms and Applications’, World Scientific Publishing Co. Pte Ltd., **2001**.

ADVANCED NUMERICAL ANALYSIS

Subject Code: MMAT1-357 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives
To provide knowledge about advanced numerical methods for solving partial differential equations.
Course Outcomes
To analyze the error incumbent in any such numerical approximation, Compare the viability of different approaches to the numerical solution of problems arising in roots of solution of non-linear equations, Finite difference methods.

Unit-I (12 Hrs.)
Iterative Methods for Linear Systems: The classical iterative methods (Jacobi, Gauss-seidel, Muller method and successive over relaxation (SOR) methods), Krylov subspace methods, Conjugate gradient, Bi-conjugate-gradient (BiCG), BiCG stability methods, Preconditioning techniques, parallel implementations.

Unit-II (11 Hrs.)
Finite Difference Methods: Explicit and implicit schemes, consistency, stability and convergence, Lax equivalence theorem, Numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

Unit-III (11 Hrs.)
Approximate Methods of Solution: Rayleigh-Ritz, Collocation and Galerkin methods, properties of Galerkin approximations, Petrov-Galerkin method, Generalized method, Spline (Quadratic, Cubic) Theory.

Unit-IV (11 Hrs.)
Finite Element Method (FEM): FEM for second order problems, one and two dimensional problems, the finite elements (elements with a triangular mesh and a rectangular mesh and three dimensional finite elements), Fourth-order problems, Hermite families of elements, Iso-parametric elements, Numerical integration.

Recommended Books:
1. M.K. Jain, S.R.K. Iyengar, and R.K. Jain, ‘Numerical Methods for Scientific and Engineering Computation’, 5th Edn., New Age international, **2008**.
2. Joe D. Hoffman, ‘Numerical methods for Engineers and Scientists’, McGraw Hill, **1993**.
3. K.E Atkinson, ‘An Introduction to Numerical Analysis’, 2nd Edn., John Wiley, **2004**.
4. R.S. Gupta, ‘Elements of Numerical Analysis’, McMillan India, **2009**
5. P. Seshu, ‘Textbook of Finite Element Analysis’, Prentice Hall India, **2003**.

NUMBER THEORY

Subject Code: MMAT1-416 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives
To introduce basic concepts of number theory and its applications in public key cryptography.
Course Outcomes
Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime,

and prime-factorization. Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.

UNIT- I (15 Hrs.)

Arithmetical Functions: Mobius function, Euler's totient function, Mangoldt function, Liouville's function, the divisor function, Relation connecting ϕ and μ Product formula for $\phi(n)$, Dirichlet product of arithmetical functions, Dirichlet inverse and Mobius invertion formula, Multiplicative function, Dirichlet multiplication, the inverse of a completely multiplicative function, Generalized convolutions.

UNIT –II (12 Hrs.)

Averages of Arithmetical Function: The Big oh notation, Asymptotic equality of functions, Euler's summation formula, Elementary asymptotic formulas, Average order of $d(n)$, $\phi(n)$, $\sigma_a(n)$, $\mu(n)$, $\Lambda(n)$, The partial sums of a Dirichlet product, application to $\mu(n)$ and $\Lambda(n)$, Legendre's identity.

UNIT- III (10 Hrs.)

Some elementary theorems on the Distribution of prime numbers Chebyshev's functions $\varphi(X)$ & $\theta(X)$, Relation Connecting $\theta(X)$ *and* $\pi(X)$, Abel's identity, equivalent forms of prime number theorem, Inequalities for $\pi(n)$ and P_n Shapiro's Tauberian theorem, Application of Shapiro's theorem.

UNIT- IV (8 Hrs.)

Elementary properties of groups, characters of finite abelian groups, the character group, Orthogonality relation for characters, Dirichlet character, Dirichlet theorem for prime of the form 4n-1 and 4n+1, Dirichlet theorem in primes on Arithmetical progression, Distribution of primes in arithmetical progression.

Recommended Books:

1. T.M. Apostol, 'Introduction to Analytic Number Theory', Springer.
2. Paul T. Bateman, 'Analytic Number Theory', World scientific.
3. 3.Murty M. Ram, 'Problems in Analytic Number Theory', Springer.
4. H. Rosen Kenneth, 'Elementary Number Theory', 6th Edn.
5. G.H. Hardy, 'An Introduction to the Theory of Numbers', 6th Edn.

FUNCTIONAL ANALYSIS

Subject Code: MMAT1-417	**L T P C** **4 0 0 4**	**Contact Hrs.-45**

Course Objectives

To provide the basic knowledge of the concepts of normed linear spaces, inner product spaces, continuous linear maps and uniform boundedness.

Course Outcomes

To analyze the basic idea of finite dimensional normed spaces and subspaces and also Identify self-adjoint transformations and apply the spectral theorem and orthogonal decomposition of inner product spaces, the Jordan canonical form to solving systems of ordinary differential equations.

Unit-I (12 Hrs.)

Normed linear space, Banach Spaces, Properties of normed spaces, Finite dimensional normed spaces and subspaces, Equivalent norms, Linear operator, Bounded and Continuous linear operators, Linear functional, Normed space of operators.

Unit-II (11 Hrs.)

Uniform boundedness Theorem, Open mapping theorem, Closed graph theorem, Projections on Banach spaces, Projection theorem.

Unit-III (11 Hrs.)

Conjugate spaces, Reflexivity, Hahn-Banach theorems for real/complex vector spaces and normed spaces, Application to bounded linear functional on C [a, b], Hilbert spaces.

Unit-IV (11 Hrs.)

Inner product spaces, Properties of inner product spaces, Orthogonal complements, Orthonormal sets, Riesz representation thm. Bessel's inequality, Hilbert – adjoint operator, Self-adjoint, Unitary and normal operators.

Recommended Books:

1. G.F. Simmons, 'Introduction to Topology and Modern Analysis', **2008.**
2. Walter Rudin, 'Functional Analysis: International Series in Pure and Applied Mathematics', McGraw Hill, inc., **1991**.
3. Erwin Kreyszig, 'Introductory Functional Analysis with Applications', John Wiley and Sons (Asia), Pvt. Ltd., **2006**.
4. George Bachman and Lawrence Narici, 'Functional Analysis', Dover, **2000**.
5. John B. Conway, 'A course in Functional Analysis', second Edn., Springer-Verlag, **2006**.

PARTIAL DIFFERENTIAL EQUATIONS

Subject Code: MMAT1-418 **L T P C** **Contact Hrs.-45**

4 0 0 4

Course Objectives

To equip the students with the analytical methods for solving different types of Partial differential equations.

Course Outcomes

Be familiar with the modeling assumptions and derivations that lead to PDEs, Recognize the major classification of PDEs and the qualitative differences between the classes of equations and be competent in solving linear PDEs using classical solution methods.

UNIT-I (10 Hrs.)

Non-linear PDE of First Order: Complete Integrals, Envelopes, Characteristics, Hamilton-Jacobi equations, Hamilton's ODE, Legengre transform, Hopf – Lax formula, Cauchy's method of characteristic; Compatible system of first order PDE, Charpit's method of solution, Solutions satisfying given conditions, Jacobi's method of solution.

UNIT-II (10 Hrs.)

Second Order PDE: Partial Differential equations of 2nd and Higher order, Classification, Examples of PDE, Solutions of Elliptic, Hyperbolic and Parabolic equations, Canonical Form, Initial and Boundary Value Problems, Lagrange-Green's identity and uniqueness by energy methods, Stability theory, energy conservation and dispersion.

UNIT-III (10 Hrs.)

Method of Solution: Separation of variables in a PDE, Laplace equation: mean value property, Weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, Existence of solution using Perron's method (without proof).

UNIT-IV (10 Hrs.)

Heat Equation: Initial value problem, Fundamental solution, Weak and strong maximum principle and uniqueness results, wave equation: uniqueness, D'Alembert's method, Method of spherical means and Duhamel's principle.

Recommended Books:

1. I.N. Snedon, 'Elements of Partial Differential Equation', 3rd Edn., McGraw Hill Book Company, 1998.
2. E.T. Copson, 'Partial Differential Equations', 2nd Edn., Cambridge University Press, **1995.**
3. Walter A. Strauss, 'Partial Differential Equations-An Introduction', 2nd Edn., **2007.**
4. Robert C. McOwen, 'Partial Differential Equations methods and application', 2nd Edn., Pearson Education Inc., **2003.**
5. Sankara Rao, 'Introduction to Partial Differential Equations', PHI, **2010.**

SEMINAR-II

Subject Code: MMAT1-419 **L T P C**
0 0 2 1

1. Each of these Courses of Seminar will consist of 100 marks (internal only) having L T P C as 0 0 2 1.
2. In the beginning of the semester, a teacher will be allocated maximum 30 students. The latter will guide/teach them how to prepare/present 15 minutes Power Point Presentation for the Seminar.
3. If there are more than 30 students in the class, then class will be divided into two groups having equal students. Each group may be allocated to a different teacher.
4. Each student will be allotted a topic by the teacher at least one week in advance for the presentation. The topic for presentation may be from the syllabus or relevant to the syllabus of the programme.
5. During the presentation being given by a student, all the other students of his/her group will attend the Seminar. The assessment/evaluation will be done by the teacher. However, Head of Department and other faculty members may also attend the Seminar, ask questions and give their suggestions.
6. This is a turn wise continuous process during the semester and a student will give minimum two presentations in a Semester.
7. For the evaluation, the following criteria will be adopted,
   (a) Attendance in Seminar: 25 Marks
   (b) Knowledge of Subject along with Q/A handling during the Seminar: 25 Marks
   (c) Presentation and Communication Skills: 25 Marks
   (d) Contents of the Presentation: 25 Marks.

ADVANCED OPERATION RESEARCH

Subject Code: MMAT1-458 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives
To introduce and deal with the various models of queueing theory, deterministic and stochastic inventory models, replacement and maintenance of equipment and network analysis.
Course Outcomes
Formulate and solve a number of classical linear programming problems, such as, the minimum spanning tree problem, the assignment problem, (deterministic) dynamic programming problem, the knapsack problem, the XOR problem, the transportation problem, the maximal flow problem, or the shortest-path problem, while taking advantage of the special structures of certain problems.

UNIT-I (12 Hrs.)

Queueing Problems: Characteristics of queueing system, Distributions in queueing systems, Poisson arrivals and exponential service times, the M/M/I, M/M/S queueing systems, Steady state solutions and their measure of effectiveness.

UNIT-II (12 Hrs.)

Inventory problems, definition, the nature and structure of inventory system, Deterministic models and their solution, multi item inventory problems, stochastic inventory models.

UNIT-III (11 Hrs.)

Replacement and Maintenance Problems: replacement of capital equipment, discounting cost, replacement in anticipation of failure, preventive maintenance, the general renewal process.

UNIT-IV (10 Hrs.)

Network Analysis: Introduction to Networks, Minimal spanning tree problem, Shortest path problem: Dijkstra's algorithm, Floyd's algorithm, Maximum flow problem, Project management: Critical path method, Critical path computations, Optimal scheduling by CPM, Review techniques (PERT).

Recommended Books

1. S.D. Sharma, 'Operation Research', Kedar Nath and Co., Meerut.
2. Kanti Swarup, P.K. Gupta and Man Mohan, 'Operations Research', 9th Edn., Sultan Chand & Sons, **2002**.
3. Friderick S. Hillier and Gerald J. Lieberman, 'Operations Research', 2nd Edn., Holden-Day Inc., USA, **1974.**
4. M.S. Bazaraa, H.D. Sherali, C.M. Shetty, 'Nonlinear Programming: Theory and Algorithms', John Wiley and Sons, **1993**.
5. S. Chandra, Jayadeva, A. Mehra, 'Numerical Optimization and Applications', Narosa Publishing House, **2013**.

ADVANCED COMPLEX ANALYSIS

Subject Code: MMAT1-459 **L T P C** **Contact Hrs.-45**

4 0 0 4

Course Objectives

To impart the advance knowledge of functions of complex variable and analytic function theory.

Course Outcomes

The student will be able to manipulate complex numbers in various representations, define and calculate limits and derivatives of functions of a complex variable. State and prove fundamental results, including: Cauchy's Theorem and Cauchy's Integral Formula, the Fundamental Theorem of Algebra, Morera's Theorem and Liouville's Theorem and use them to prove related results.

UNIT-I (11 Hrs.)

Fundamental theorems connected with zeros of analytic functions, the argument (counting) principle, Rouche's theorem, Fundamental theorem of algebra, Morera's theorem, Normal limits of analytic functions, Hurwitz's theorem, Normal limits of univalent functions, Open mapping theorem, Inverse function theorem.

UNIT-II (10 Hrs.)

Implicit function theorem, Analyticity of the explicit function, Riemann surfaces for multivalued functions, Direct and indirect analytic continuation, Lipschitz nature of the radius of convergence, Analytic continuation along paths via power series.

UNIT-III (12 Hrs.)

Monodromy theorem (first version and second version), The Mean value property, Harmonic functions, Maximum principle (with proof), Schwarz's lemma (with proof), Differential or infinitesimal schwarz's lemma.

UNIT-IV (12 Hrs.)

Pick's lemma, Hyperbolic geometry on the unit disc, Arzela-ascoli theorem (with proof), Montel's theorem (with proof), Riemann mapping theorem (with proof).

Recommended Books

1. L.V. Ahlfors, 'Complex Analysis', 2nd Edn., McGraw Hill International Student Edn., **1990.**
2. E.T. Capson, 'An Introduction to the Theory of Functions of a Complex Variable', Oxford University Press, **1995.**
3. Theodore Gamelin, 'Complex Analysis (UTM)', Springer, **2003**.
4. S. Ponnusamy & Herb Silverman, 'Complex Variables with Applications', Birkhaeuser,

Boston, **2006.**

FRACTIONAL CALCULAS

Subject Code: MMAT1-460 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives

To understand the concepts of Riemann liouville fractional integrals and derivatives of the fractional integral, The Weyl fractional calculus and Fractional differential equations.

Course Outcomes

The student will be able to know the concept of Riemann liouville fractional integrals, Derivatives of the fractional integral, Leibniz's formula for fractional integrals.

UNIT-I (12 Hrs.)

Riemann liouville Fractional Integrals: Definition, some examples, law of exponents, Fractional integrals of some functions namely binomial function, Exponential, Hyperbolic and trigonometric functions, Bessel's functions, Hyper-geometric function and the fox's H- function, Dirichlet's formula.

UNIT-II (10 Hrs.)

Derivatives of the fractional integral and the fractional integral of derivatives, Laplace transform of the fractional integral, Leibniz's formula for fractional integrals, Derivatives, Leibniz's formula of fractional derivatives.

UNIT-III (10 Hrs.)

The Weyl fractional calculus – Definition of weyl fractional integral weyl Fractional derivatives, Leibniz formula for Weyl fractional integral and simple applications.

UNIT-IV (13 Hrs.)

Fractional differential equations: Introduction, Laplace transform, Linearly independent solutions, solutions of the homogeneous equations, Solution of the non-homogeneous fractional Differential equations, Reduction of fractional differential equations to ordinary differential equations. Semi differential equations.

Recommended Books:

1. K.B. Oldham & J. Spanier, 'The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order', Dover Publications Inc., **2006**.
2. K.S. Miller & B. Ross, 'An Introduction to the Fractional Calculus and Fractional Differential Equations Hardcover', Wiley-Blackwell, **1993**.
3. Sameko, Kilbas and Mariche, 'Fractional integrals and Derivatives Theory and Applications', Gorden and Branch Science Publishers.

GRAPH THEORY

Subject Code: MMAT1-461 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives

To impart basic knowledge and concepts of graph theory for its use in various practical applications in science and engineering.

Course Outcomes

To understand the concept of Graph Theory, their properties, also understand the concept of Matching and factors, edges, connectivity and paths.

UNIT-I (12 Hrs.)

Fundamental Concepts: Graph- Definitions an examples, graphs as models, Matrices and isomorphism, paths, Connected graphs, Bipartite graphs, Externality vertex degree, Pigeonhole principal, Turan's theorem, Degree sequences, Graphic sequences, Degree and digraphs.

UNIT-II (10 Hrs.)

Tree and distances: Properties of tree, Distance in graphs, Stronger results, Disjoint spanning trees, Shortest paths, Tress in computer science, Eulerian circuits.

UNIT-III (12 Hrs.)

Matching and Factors: Matching in bipartite graphs, Maximum matching, Hall's matching conditions, mismatching in bipartite graphs, sets, applications and algorithms, maximum bipartite matching, weighted bipartite matching, in general graphs, Tutte's 1- factor theorem, f-factors of graphs.

UNIT-IV (11 Hrs.)

Connectivity and Paths: Cuts connectivity, Edge-connectivity, Blocks, 2-connected graphs, Connectivity of digraphs, k connected and k-edge connected graphs, Applications of merger's theorem, Network flow problems, Maximum network flow, Integral flows.

Edges and cycles: Line graph and edge coloring, Hamiltonian cycles: Necessary and sufficient conditions.

Recommended Books:

1. Douglas B. West, 'Introduction to Graph Theory', Prentice-Hall, New Delhi, **1999**.
2. F. Harary, 'Graph Theory', Nsrosa, New Delhi.
3. Narsing Deo, 'Graph Theory', Prentice Hall, India.

SAMPLING TECHNIQES AND ESTIMATION THEORY

Subject Code: MMAT1-462 | **L T P C 4 0 0 4** | **Contact Hrs.-45**

Course Objectives

To acquaint the students with the theory of decision problem and different estimators and various testing hypothesis.

Course Outcomes

To understand the idea of Sampling and its types. Also to know the concept of Estimation Theory, Distributions and Sampling Tests- F- Test, Chi square test.

UNIT-I (10 Hrs.)

Fundamentals of sampling, Simple random sampling, Stratified sampling, Ratio method of estimation, Regression method of estimation, Varying probability sampling

UNIT-II (10 Hrs.)

Double sampling, Two stage sampling, Systematic sampling, Cluster sampling, Sampling in successive occasion, Non-sampling errors

UNIT-III (13 Hrs.)

Theory of Estimation: Different types of estimators, Maximum likelihood estimator and their properties, Other methods of estimation, Interval estimation, Sampling theory; Chi-square distribution, Fisher's theorem, Coach theorem, distributing of non-control chi-square Testing of Homogenate with the help of chi-square Bartiletts, tests of homogeneity of variance and correlation coefficients, Behrens fisher test for comparing the means of two normal populations.

UNIT-IV (12 Hrs.)

Distribution of non-central F. Student Newman Rules Test, Tests for linearity of regression, Multiple regression, Testing of hypothesis, Curvilinear regression Newman-pearsons test hypothesis, Muitaracte analysis characteristic function, Distribution of quadratic forms, Distribution correlation coefficient in the non-null case, Distribution of partial correlation coefficient, Distribution of multiple correlation in the null case and non-null case, Distribution of Hotelling's T2 and its uses, Distribution of Mohlnopis D2.

Recommended Books:

1. Z. Govindrajalu, 'Elements of Sampling Theory and Methods', Prentice Hall, **1999.**

2. P. Mukhopadhyaya, 'Sampling', Prentice Hall of India, **1998.**
3. W.G. Cochran, 'Sampling Techniques', Wiley.
4. W. Feller, 'Mathematical Statistics', Vol. 1, 2.
5. M.G. Kendall, 'The Advance Theory of Statistics'.

FUZZY SET THEORY AND ITS APPLICATIONS

Subject Code: MMAT1-463 **L T P C** **Contact Hrs.-45**
4 0 0 4

Course Objectives:
To introduce the concept of fuzzy sets, operations on fuzzy sets, their relations and logic of fuzzy sets.

Course Outcomes
To understand the main subject of fuzzy sets learns crips and fuzzy set theory and to decide the difference between crips set and fuzzy set theory. Also to make calculation on fuzzy set theory and to gain the methods of fuzzy logic. Recognize fuzzy semigroups and fuzzy ideals using membership function.

UNIT-I (12 Hrs.)

Classical and Fuzzy Sets: Classical sets vs Fuzzy Sets – Need for fuzzy sets – Definition and Mathematical representations, Membership Function, a-cuts, Properties of a-cuts, Decomposition Theorems, Extension Principle.

Operations on Fuzzy Sets: Compliment, Intersections, Unions, Operations on [0,1] – Fuzzy negation, triangular norms, Combinations of operations, Aggregation Operations.

UNIT-II (11 Hrs.)

Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on intervals and Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations.

Fuzzy Relations: Crisp and Fuzzy Relations, Projections and Cylindric Extensions, Binary Fuzzy Relations, Binary Relations on single set, Equivalence, Compatibility and Ordering Relations, Morphisms, Fuzzy Relation Equations.

UNIT-III (11 Hrs.)

Possibility Theory: Fuzzy Measures, Evidence Theory, Necessity and Belief Measures, Probability Measures vs. Possibility Measures.

Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges, Fuzzy If Then Rule Base, Inference Engine, Takagi-Sugeno Fuzzy Systems, Function Approximation.

UNIT-IV (11 Hrs.)

Uncertainty based Information: Information and Uncertainty, Non specificity of Fuzzy and Crisp sets, Fuzziness of Fuzzy Sets. Applications of Fuzzy Logic.

Recommended Books:

1. G.J. Klir and B. Yuan, 'Fuzzy sets and Fuzzy logic: Theory and Applications', PHI, **1995**.
2. H.J. Zimmermann, 'Fuzzy Set Theory and its Applications', Allied Publishers, **1991**.
3. Kevin M. Passino and Stephen Yurkovich, 'Fuzzy Control', Addison Wesley Longman, **1998**.
4. Michal Baczynski and Balasubramaniam Jayaram, 'Fuzzy Implications', Springer Verlag, Heidelberg.