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THE NATIONAL COLLEGE

(AUTONOMOUS)

JAYANAGAR, BANGALORE – 560 070

POST GRADUATE DEPARTMENT OF MATHEMATICS

REGULATIONS, SCHEME AND SYLLABUS

(Approved in the BOS meeting held on 25-08-2020)

for M.Sc. MATHEMATICS

(Semester System - Y2K20 Scheme)

w. e. f. academic year 2020-21

M.Sc. - MATHEMATICS COURSE
SEMESTER SCHEME REGULATIONS-2019

Name of the Course	M.Sc. - Mathematics
Duration	Four Semesters Course
Contents	In first semester, there are five theory and one practical core subject papers, and one theory soft core paper for study and examination.
	In second semester, there are five theory and one practical core subject papers, and one theory soft core paper for study and examination.
	In third semester there are five theory and one practical core subject papers, and one open elective paper for study and examination.
	In fourth semester there are two compulsory and three elective theory papers and Project work for study and examination.
Medium of Instruction	English

REGULATIONS:

I. Attendance: As per The National College-autonomous regulations for PG science courses.

II. Examination:

1 After every semester term, an end semester examination is conducted.

2 (i) First and second semester will have five theory papers (core subjects) where each paper shall carry a maximum of 100 marks of 4 credits and one theory (soft core) shall carry a maximum of 100 marks of 2 credits. ii) One practical paper where each paper shall carry a maximum of 50 marks of 2 credits.

3 Third semester will have i) Five theory papers (core subjects) where each paper shall carry a maximum of 100 marks of 4 credits and one open elective paper shall carry a maximum of 100 marks of 2 credits. ii) One practical papers where each paper shall carry a maximum of 50 marks of 2 credits.

4 Fourth semester will have i) Five theory papers and project work where each shall carry a maximum of 100 marks of 4 credits.

5 The composition of examination and internal assessment marks for each i) Theory paper is 70 and 30. ii) Practical paper is 35 and 15, respectively.

6 Each of the theory papers and practical papers will have examination of 3 hrs. duration.

7 The internal assessment for theory papers would be based on tests, attendance, assignments and seminars and for practical papers would be based on tests and assignment/attendance.

III. Classification of Successful Candidates: As per The National College-autonomous regulations for PG science courses.

IV. Challenge Valuation: As per The National College-autonomous regulations for PG science courses.

V. Provisions for Repeaters: As per The National College-autonomous regulations for PG science courses.

Note:

1. The maximum number of students taking an elective shall be 15 (preferably).
2. The electives will be offered to the students through counseling in the department based on the marks obtained in the first two semesters.

Break-up of practical mark allotment (of 35 marks)

- Practical Record : 5 marks
- Writing and Execution of Two Programs : 24 marks
- Viva : 6 marks

Break-up of internal assessment marks for practical (of 15 marks)

- Attendance : 05 marks
- One internal test: 10 marks

Break up of internal assessment marks for theory papers (30 marks)

- Two internal tests: 15 marks
- Attendance: 05 marks
- Assignments: 05 marks
- Seminar: 05 marks

Break up of project work marks allotment (100 marks)

- Project report evaluation
  (Two Evaluations- One Internal and One External): 70 marks
- Viva : 10 marks
- Project presentation: 20 marks

Proceedings of The Board of Studies meeting of Post Graduate Department of Mathematics held at, The National College, Jayanagar, Bangalore-560070 on 25th August 2020.

The following members attended the meeting:

1	Dr. K. R. Madhura	Madhura K.R
2	Prof. I. S. Shivakumara	
3	Dr. H. G. Nagaraja	[illegible] 25/08/20
4	Dr. Medha Itagi Huilgol	[illegible] 25/08/20.
5	Dr. Ramesh B. Kudenatti	[illegible]
6	Dr. Vasant Kumar Jain	
7	Ms. Kavya G. M.	[illegible]
8	Dr. G Kalpana	
9	Ms. Akhila P. A.	Akhila. P.A
10	Ms. Soniya Hegde	Soniya Hegde
11	Mr. Vadiraj G	VadiRaj

Proceedings of the meeting

1. The Chairman of the Postgraduate department of Mathematics welcomed the members of Board of Studies to the meeting.
2. Chairman briefed about the agenda of the meeting and read out the syllabus.
3. A discussion was held on the suitability of adopting the syllabus with minor modifications.
4. Number of teaching hours in papers such as
   - M101T: Algebra I
   - M105T: Discrete Mathematics
   - M201T: Algebra II
   - M202T: Complex Analysis
   - M203T: Topology II
   - M204T: Partial Differential Equations
   - M302T: Functional Analysis
   - M401T: Measure and Integration
   - M403T(A): Graph Theory

   Were merged and realloted.
5. The modifications made with regard to the syllabus and suggestions given were incorporated.
6. The chairman thanked all the members and the meeting was concluded.

Place: Bangalore
Date: 25 August, 2020

Coordinator
P. G. Department of Mathematics
The National College,
Jayanagar, Bangalore - 5600070

Head
PG Dept of Mathematics
The National College
Autonomous
Jayanagar, Bangalore-560 070

Structure of M.Sc- Mathematics Syllabus

Subjects	Papers		Instruction Hrs/Week	Duration of Exam (Hrs)	Marks			Credits
					IA	Exam	Total	
I Semester								
Core Subjects	**Theory**	**M101T :** Algebra-I	4	3	30	70	100	4
		M102T : Real Analysis	4	3	30	70	100	4
		M103T : Topology-I	4	3	30	70	100	4
		M104T : Ordinary Differential Equations	4	3	30	70	100	4
		M105T : Discrete Mathematics	4	3	30	70	100	4
	Practicals	**M106P :**Maxima Practicals for Discrete Mathematics	3	3	15	35	50	2
Soft Core	**Theory**	**M107SC :** An Introductory Course on Cryptography	3	3	30	70	100	2
Total Credits per semester								**24**
II Semester								
Core Subjects	**Theory**	**M201T :** Algebra - II	4	3	30	70	100	4
		M202T : Complex Analysis	4	3	30	70	100	4
		M203T : Topology-II	4	3	30	70	100	4
		M204T : Partial Differential Equations	4	3	30	70	100	4
		M205T : Numerical Analysis-I	3	3	30	70	100	4
	Practicals	**M206P :** Scilab Practicals for Numerical Analysis-I	3	3	15	35	50	2
Soft Core	**Theory**	**M207SC :** Continuum Mechanics	3	3	30	70	100	2
Total Credits per semester								**24**

III Semester								
Core Subjects	**Theory**	**M301T :** Linear Algebra	4	3	30	70	100	4
		M302T : Functional Analysis	4	3	30	70	100	4
		M303T : Differential Geometry	4	3	30	70	100	4
		M304T : Fluid Mechanics	4	3	30	70	100	4
		M305T : Numerical Analysis-II	4	3	30	70	100	4
		M306P: Scilab Practicals for Numerical Analysis-II	4	3	15	35	50	2
Open Elective		**M307OE :** Operation Research	2	3	30	70	100	2
Total Credits per semester								**24**
IV Semester								
Core Subjects and Electives	**Theory**	**M401T :** Measure and Integration	4	3	30	70	100	4
		M402T: Mathematical Methods	4	3	30	70	100	4
		M403T(A) : Graph Theory **M403T(B) :** Magnetohydrodynamics **M403T(C):** Finite Element Methods with Applications **M403T(D):** Computational Fluid Dynamics(CFD) **M403T(E):** Mathematical Modeling and Simulation	3x4	3x3	3x30	3x70	3x100	3x4
	Project Work		8	Report Evaluation			100	4
Total Credits Per Semester								**24**
Program Grand Total Of Credits								**96**

MISSION AND VISION OF THE NEW SYLLABUS IN MATHEMATICS

Mission

- Improve retention of mathematical concepts in the student.
- To develop a spirit of inquiry in the student.
- To improve the perspective of students on mathematics as per modern requirement.
- To initiate students to enjoy mathematics, pose and solve meaningful problems, to use abstraction to perceive relationships and structure and to understand the basic structure of mathematics.
- To enable the teacher to demonstrate, explain and reinforce abstract mathematical ideas by using concrete objects, models, charts, graphs, pictures, posters with the help of FOSS (Free and Open Source Software) tools on a computer.
- To make the learning process student-friendly by having a shift in focus in mathematical teaching, especially in the mathematical learning environment.
- Exploit techno-savvy nature in the student to overcome math-phobia.
- Propagate FOSS (Free and Open Source Software Tools) amongst students and teachers as per vision document of National Mission for Education.
- To set up a mathematics laboratory in every college in order to help students in the exploration of mathematical concepts through activities and experimentation.
- To orient students towards relating Mathematics to applications.

Vision

- To remedy Math phobia through authentic learning based on hands-on experience with computers.
- To foster experimental, problem-oriented and discovery learning of mathematics.
- To show that ICT (Information Communication Technology) can be a panacea for quality and efficient education when properly integrated and accepted.
- To prove that the activity-centered mathematics laboratory places the student in a problem solving situation and then through self-exploration and discovery habituates the student into providing a solution to the problem based on his or her experience, needs, and interests.
- To provide greater scope for individual participation in the process of learning and becoming autonomous learners.
- To provide scope for greater involvement of both the mind and the hand this facilitates cognition.
- To ultimately see that the learning of mathematics becomes more alive, vibrant, relevant and meaningful; a program that paves the way to seek and understand the world around them. A possible by-product of such an exercise is that math-phobia can be gradually reduced amongst students.
- To help the student build interest and confidence in learning the subject.

POSTGRADUATE COURSE

Objectives

1. To provide advanced knowledge and expertise in order to produce competent, creative and imaginative postgraduate students with a strong scientific acumen.
2. To promote independent and collaborative learning.
3. Provide training to develop sound skills and acquire the latest theoretical and practical knowledge in the chosen fields of study.

M.SC in MATHEMATICS

Objectives

1. To provide specialization in Mathematics and its related fields.
2. To provide guidance to incorporate specific study from one branch of mathematics into another.
3. To develop motivation for research as well as to provide efficiency towards seeking career opportunities in mathematics education, finance, applied mathematics and other math related fields.

I SEMESTER

I. M101T- ALGEBRA I

Course Objectives

This course will:

1. Present the relationships between abstract algebraic structures like Groups and Rings.
2. Discuss the importance of algebraic properties relative to working within various number systems.
3. Develop the ability to form and evaluate conjectures

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Demonstrate the applications of algebraic techniques to identify reducible and irreducible polynomials, symmetric and asymmetric structures generate prime numbers used to protect confidential data through encryption using Sylow's theorems.

II. M102T – REAL ANALYSIS

Course Objectives

This course will:

1. Define the limit of a function at a value, a limit of a sequence, continuity of a function and uniform continuity of a function and the Cauchy criterion and prove various theorems about limits of sequences and series functions and emphasize the proof development.
2. Prove the Inverse function theorem, Implicit function theorem, Rank theorem and emphasize the proofs' development.
3. Define Riemann, Riemann-Stieltjes integrals and sums. Prove various theorems about Riemann and Riemann-Stieltjes sums, integrals and emphasize the proofs' development of various integrating techniques like integration by parts, change of variable.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply learnt methods to develop various integration techniques, establish various numerical methods by developing theorems on equations of real coefficients.

III. M103T – TOPOLOGY – I

Course Objectives

This course will:

1. Explain the notion of metric space, construct the topology by using the metric and using this topology identify the continuity of the functions which are defined between metric spaces.
2. Define the notion of topology, construct various topologies on a general set which is not empty by using different kinds of techniques, compare these topologies and identify the special subsets of the topology that are called base and subbase which generate elements of the topology.
3. Construct topologies which accept a given family of sets base or subbase.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply the learnt methodologies in the fields of image processing, network topologies, robotics etc.

IV. M104T – ORDINARY DIFFERENTIAL EQUATIONS

Course Objectives

This course will:

1. Provide the standard methods for solving ordinary differential equations.
2. Classify the ordinary differential equations according to order and linearity as well as distinguish the initial and boundary value problems.

Course Outcomes

Students will be able to:

1. Create and analyze mathematical modelling using differential equations which helps to solve problems in different fields such as circuits, population modelling etc.
2. Demonstrate the ability to integrate knowledge and ideas of differential equations by analyzing their solutions to explain resulting physical process.

V. M105T – DISCRETE MATHEMATICS

Course Objectives

This course will:

Provide an introduction to the study of Discrete Mathematics, a branch of contemporary mathematics that develops reasoning and problem-solving abilities, with an emphasis on proof. Topics include Logic, Mathematical Reasoning and proof, Set Theory, Combinatorics and Graph Theory. This course is intended for students capable of and interested in progressing through the concepts of discrete mathematics in more depth and at an accelerated rate. Graphing calculators are an integral part of this course.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Use logical techniques effectively to analyze basic discrete structures and algorithms. Use logical notations to define and reason about fundamental mathematical concepts and also apply graph theory models to solve real world problems.

VI. M106P – MAXIMA PRACTICLAS FOR DISCRETE MATHEMATICS

Course Objectives

This course will:

1. Provide knowledge about programming of discrete mathematical problems like recurrence relations, Hasse diagrams, pcnf, pdnf, finding shortest distance etc. using maxima tools.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Program and also establish different algorithms of all the Discrete Mathematical problems using Maxima

VII. M107SC – AN INTRODUCTORY COURSE ON CRYPTOGRAPHY

Course Objectives

This course will:

1. Enable the students to learn fundamental concepts of cryptography and number theory.
2. Help to identify computer and network security threats, classify the threats and develop models to resolve it.
3. Explain the encryption and decryption of messages using Caesar cipher, Palyfair cipher, Hill cipher, Block cipher, Stream cipher, RSA etc.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply learnt methods to develop security models to prevent, detect and recover from the cyber-attacks and design algorithms to secure confidential data.

FIRST SEMESTER

PAPER - M101T: ALGEBRA-I
(4 Hours/week)

Recapitulation: Groups, Subgroups, Cyclic groups, Normal subgroups, Quotient groups, Homomorphism, Types of homomorphism. Permutation groups, Symmetric groups, Cycles and alternating groups, Dihedral groups, Isomorphism theorems and its related problems, Automorphisms, Inner automorphisms, groups of automorphisms and inner automorphisms and their relation with centre of a group. Group action on a set, Orbits and Stabilizers, The orbit-stabilizer theorem, The Cauchy-Frobenius lemma, Conjugacy, Normalizers and Centralizers. **13 Hrs.**

Class equation of a finite group and its applications. Sylow's groups and subgroups, Sylow's theorems for a finite group, Applications and examples of p-Sylow subgroups. Solvable groups, Simple groups, Applications and examples of solvable and simple groups, Jordan – Holder Theorem. **13 Hrs.**

Recapitulation: Rings, Some special classes of rings (Integral domain, division ring, field). Homomorphism of rings, Kernel and image of homomorphism of rings, Isomorphism of rings, Ideals and quotient rings, Fundamental theorem of homomorphism of rings. Theorems on principal, maximal and prime ideals, Field of quotients of an integral domain, Imbedding of rings. **13 Hrs.**

Euclidean rings, Prime and relatively prime elements of a Euclidean ring, Unique factorization theorem, Fermat's theorem, Polynomial rings, The division algorithm. Polynomials over the rational field, Primitive polynomial, Content of a polynomial. Gauss lemma, Eisenstein criteria, Polynomial rings over commutative rings, Unique Factorization Domains. **13 Hrs.**

TEXT BOOKS

1. I. N. Herstein, "Topics in Algebra", Second edition, John Wiley and Sons, 2007.
2. Surjeet Singh and Qazi Zameeruddin, "Modern Algebra", Vikas Publishing House, 1994.
3. N. Jacobson, "Basic Algebra-I", Second edition, Dover Publications, 2009.
4. J. B. Fraleigh, "A First Course in Abstract Algebra", Seventh edition, Addison-Wesley Longman, 2002.

REFERENCE BOOKS

1. M. Artin, "Algebra", Prentice Hall of India,1991.
2. Darek F Holt, Bettina Eick and Eamonaa, Obrien, "Handbook of computational group theory", Chapman & Hall/CRC Press, 2005.
3. Joseph A Gallian, "Contemporary Abstract Algebra," Fourth edition, Narosa Book Distributors, 2008.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER – M102T: REAL ANALYSIS
(4 Hours/ week)

The Riemann – Stieltjes Integral: Definitions and existence of the integral, Linear properties of the integral, The integral as the limit of sums, Integration and Differentiation, Integration of vector valued functions. Functions of bounded variations – First and second mean value theorems, Change of variable rectifiable curves. **18 Hrs.**

Sequence and series of Functions: Pointwise and Uniform Convergence, Cauchy Criterion for uniform convergence, Weierstrass M-test, Uniform convergence and continuity, Uniform convergence and Riemann – Stieltjes Integration, Uniform convergence and differentiation. Uniform convergence and bounded variation-Equicontinous families' functions, Uniform convergence and boundedness, The Stone-Weierstrass theorem and Weierstrass approximation of continuous function, Illustration of theorem with examples-properties of power series, Exponential and logarithmic functions, Trigonometric functions. Topology of $\mathbb{R}^n$, K-cell and its compactness, Heine-Borel Theorem. Bolzano-Weierstrass theorem, Continuity, Compactness and uniform continuity. **18 Hrs.**

Functions of several variables, Continuity and differentiation of vector-valued functions, Linear transformation of $\mathbb{R}^k$ properties and invertibility, Directional derivative, Chain rule, Partial derivative, Hessian matrix and examples. The Inverse Function Theorem and its illustrations with examples. The Implicit Function Theorem and illustration and examples. The Rank Theorem illustration and examples. **16 Hrs.**

TEXT BOOKS

1. W. Rudin, "Principles of Mathematical Analysis", McGraw-Hill, 1983.
2. T. M. Apostol, "Mathematical Analysis", New Delhi, Narosa, 2004.

REFERENCE BOOKS

1. S. Goldberg, "Methods of Real Analysis", Oxford & IBH, 1970.
2. J. Dieudonne, "Treatise on Analysis", Vol.1, Academic Press, 1960.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER – M103T: TOPOLOGY - I
(4 Hours/week)

Finite and Infinite sets. Denumerable and Non denumerable sets, Countable and Uncountable sets. Equivalent sets. Concept of Cardinal numbers, Schroeder-Bernstein Theorem. Cardinal number of a power set – Addition of Cardinal numbers, Exponential of Cardinal numbers, Examples of Cardinal Arithmetic, Cantor's Theorem. Card $X <$ Card $\wp(X)$. Relations connecting $\aleph_0$ and c. Continuum Hypothesis. Zorn's lemma (statement only). **14 Hrs.**

Definition of a metric. Bolzano – Weierstrass theorem. Open and closed balls. Cauchy and convergent sequences. Complete metric spaces. Continuity, Contraction mapping theorem. Banach fixed point theorem, Bounded and totally bounded sets. Cantor's Intersection Theorem. Nowhere dense sets. Baire's category theorem. Isometry. Embedding of a metric space in a complete metric space. **12 Hrs.**

Topology: Definition and examples, Open and closed sets. Neighborhoods and limit points. Closure, Interior and boundary of a set. Relative topology. Bases and sub-bases. Continuity and Homeomorphism, Pasting lemma. **14 Hrs.**

Connected spaces: Definition and examples, Connected sets in the real line, Intermediate value theorem, Components and path components, local connectedness and path connectedness. **12 Hrs.**

TEXT BOOKS

1. J. R. Munkers, "Topology", Second edition, Prentice Hall of India, 2007.
2. W.J. Pervin, "Foundations of General Topology", Academic Press, 1964.
3. G. F. Simmons, "Introduction to Topology and Modern Analysis", Tata McGraw-Hill, 1963.

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REFERENCE BOOKS

1. J. Dugundji, "Topology", Prentice Hall of India, 1975.
2. G J.L. Kelley, "General Topology", Van Nostrand, Princeton, 1955.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER - M 104T : ORDINARY DIFFERENTIAL EQUATIONS
(4 Hrs./week)

Linear differential equations of n^{th} order, Fundamental sets of solutions, Wronskian-Abel's identity, Theorem on linear dependence of solutions, Adjoint-self-adjoint linear operator, Green's formula, Adjoint equations, The n^{th} order non-homogeneous linear equations-Variation of parameters- Zeros of solutions- Comparison and separation theorems. **13 Hrs.**

Fundamental existence and uniqueness theorem. Dependence of solutions on initial conditions, Existence and uniqueness theorem for higher order and system of differential equations – Eigenvalue problems – Sturm-Liouville problems -Orthogonality of eigen functions – Eigen function expansion in a series of orthonormal functions- Green's function method. **13 Hrs.**

Power series solution of linear differential equations- Ordinary and singular points of differential equations, Classification into regular and irregular singular points, Series solution about an ordinary point and a regular singular point – Frobenius method-Hermite, Laguerre, Chebyshev and Gauss Hypergeometric equations and their general solutions. Generating function, Recurrence relations, Rodrigue's formula-Orthogonality properties. Behaviour of solution at irregular singular points and the point at infinity. **13 Hrs**.

Linear system of homogeneous and non-homogeneous equations (matrix method). Linear and Non-linear autonomous system of equations - Phase plane - Critical points – stability - Liapunov direct method – Limit cycle and periodic solutions-Bifurcation of plane autonomous systems. **13 Hrs.**

TEXT BOOKS

1. G.F. Simmons, "Differential Equations", TMH Edition, New Delhi, 1974.
2. M.S.P. Eastham, "Theory of Ordinary Differential Equations", Van Nostrand, London, 1970.
3. S.L. Ross, "Differential equations", Third edition, John Wiley & Sons, New York, 1984.

REFERENCE BOOKS

1. E.D. Rainville and P.E. Bedient, "Elementary Differential Equations", McGraw -Hill, New York, 1969.
2. E.A. Coddington and N. Levinson, "Theory of Ordinary Differential Equations", McGraw-Hill, 1955.
3. A.C. King, J. Billingham and S.R. Otto, "Differential Equations", Cambridge University Press, 2006.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER - M 105T : DISCRETE MATHEMATICS
(4 Hours/week)

Logic: Introduction to logic, Rules of Inference (for quantified statements), Validity of Arguments, Normal forms. Methods of proof: Direct, Indirect proofs, Proof by contradiction, Proof by cases, etc.
Counting Techniques: The product rule, The sum rule, The inclusion–exclusion principle, The Pigeonhole Principle and examples. Simple arrangements and selections, Arrangements and selections with repetitions, Distributions, Binomial Coefficients. Modeling with recurrence relations with examples of Fibonacci number and the tower of Hanoi problem, Solving recurrence relations. Divide-and-Conquer relations with examples (no theorems). Generating functions, Definition with examples, solving recurrence relations using generating functions, Exponential generating functions. Difference equations. Definition and types of relations. Representing relations using matrices and digraphs, Closures of relations, Paths in digraphs, Transitive closures, Warshall's Algorithm. Order relations, Posets, Hasse diagrams, External elements, Lattices. **26 Hrs.**

Introduction to graph theory, Types of graphs, Basic terminology, Subgraphs, Representing graphs as incidence matrix and adjacency matrix. Graph isomorphism. Connectedness in simple graphs. Paths and cycles in graphs. Distance in graphs: Eccentricity, Radius, Diameter, Center, Periphery. Weighted graphs Dijkstra's algorithm to find the shortest distance paths in graphs and digraphs. Euler and Hamiltonian Paths. Necessary and sufficient conditions for Euler circuits and paths in simple, Undirected graphs. Hamiltonicity: noting the complexity of hamiltonicity, Traveling Salesman's Problem, Nearest neighbor method. Planarity in graphs, Euler's Polyhedron formula. Kuratowski's theorem (statement only). Vertex connectivity, Edge connectivity, Covering, Independence. Trees, Rooted trees, Binary trees, Trees as models. Properties of trees. Minimum spanning trees. Minimum spanning trees. Prim's and Kruskul's Algorithms. **26 Hrs.**

TEXT BOOKS

1. C. L. Liu, "Elements of Discrete Mathematics", Tata McGraw-Hill, 2000.
2. Kenneth H. Rosen, "Discrete Mathematics and its Applications", Sixth edition, WCB McGraw-Hill, 2004.

REFERENCE BOOKS

1. J.P. Tremblay and R.P. Manohar, "Discrete Mathematical Structures with applications to computer science", McGraw-Hill, 1975.
2. F. Harary, "Graph Theory", Addition Wesley, 1969.
3. J. H. Van Lint and R. M. Wilson, "A course on Combinatorics", Cambridge University Press, 2006.
4. Allan Tucker, "Applied Combinatorics", John Wiley & Sons, 1984.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER - M 106P : MAXIMA PRACTICALS FOR DISCRETE MATHEMATICS
(3 Hours/week)

List of programs

1. Logical operators: And, Or, Not, Nand, Nor, Xor, Implies, Equivalent ( ), Unequal.
2. Finding CNF and DNF.
3. Solving recurrence/ difference relations (with and without boundary conditions).
4. Finding a generating function (given a sequence).
5. Hasse' diagrams.
6. Lattice properties including the extremal values.
7. Traveling Salesman Problem.
8. Representing relations using digraphs and finding the nature of the given relation.
9. Warshall's algorithm to find transitive closure.
10. Lattice properties with extremal elements.
11. Graph Isomorphism.
12. Dijkstra's algorithm to find shortest distance paths and lengths.
13. Checking given graph to be Eulerian.
14. Nearest Neighbor method.
15. Determining minimum spanning tree using Prim's/ Kruskal's algorithm.

PAPER M107SC : AN INTRODUCTORY COURSE ON CRYPTOGRAPHY
(3 Hours/week)

Introduction- Encryption and Secrecy – The objective of Cryptography – Cryptographic protocols. **6 Hrs.**

Mathematical background- Number Theory – Introduction- Divisibility and the Euclidean algorithm. Modular Arithmetic- Integer factorization problem, Congruence's- Pollard's rho factoring- Elliptic curve factoring- Discrete logarithm problem. **11 Hrs.**

Finite fields- Basic properties- Arithmetic of polynomials- Factoring polynomials over finite fields- Square free factorization. **8 Hrs.**

Cryptography: Some simple cryptosystems. Enciphering matrices. Symmetric key encryption- Stream Ciphers- Block Ciphers- DES. **7 Hrs.**

Public Key: Public Key cryptography-Concepts of public key cryptography-Modular arithmetic- RSA- Discrete logarithm. **7 Hrs.**

TEXT BOOKS

1. Hans Delfs and Helmut Knebl, "Introduction to Cryptography", Springer Verlag, 2002.C.
2. Neal Koblitz, "A course in Number Theory and Cryptography", Springer Verlag, New York, 1987.
3. Tom M. Apostol, "Introduction to Analytic Number Theory", Springer Verlag, New York, Heidelberg Berlin, 1976.

REFERENCE BOOKS

1. William Stallings, "Cryptography and Network Security", Prentice Hall of India, 2000.
2. Alfred J. Menezes, Paul C. Van Oorchot, Scott A. Vanstone, "Handbook of Applied Cryptography", CRC Press, 2000.

Pattern of Question Paper: Five full questions out of eight are to be answered.

II SEMESTER

I. M201T –ALGEBRA-II

Course Objectives

This course will:

1. Present the relationships between abstract algebraic structures like Fields and Modules.
2. Discuss the importance of algebraic properties relative to solve equations within various number systems like rational, real and complex numbers.
3. Develop the ability to form and evaluate conjectures as well as theorems.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Construct polynomials without using a scale and a protractor but with exact dimensions using Galois Theory and also learn commutative algebra techniques by adopting morphisms study.

II. M202T – COMPLEX ANALYSIS

Course Objectives

This course will:

1. Perform algebra with complex numbers, compute sums, products, quotients, conjugate, modulus, and argument of complex numbers, and also find all integral roots and all logarithms of nonzero complex numbers.
2. Identify complex-differentiable functions, express complex differentiable functions as power series and also find parametrizations of curves, and use Cauchy's integral theorem and formula to compute line integrals.
3. Use the residue theorem and identify the isolated singularities of a function and determine whether they are removable, poles, or essential and also compute innermost Laurent series at an isolated singularity, and determine the residue.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Demonstrate the applications of complex numbers in major areas of engineering - signal processing and control theory and also in mathematical physics for solving boundary problems on very complicated domains

III. M203T – TOPOLOGY-II

Course Objectives

This course will:

1. Explain the notion of separation axioms, I and II countability, compactness and compactification.
2. Construct various separated topological spaces like Hausdorff space, Tychonoff spaces etc., and provide different properties like topological and hereditary properties for the same.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply the learnt techniques to separate points sets and spaces which in turn has its direct applications in the fields of molecular topology, robotics, image processing and bioinformatics.

IV. M204T – PARTIAL DIFFERENTIAL EQUATIONS

Course Objectives

This course will:

1. Provide the fundamental importance of partial differential equations.
2. Classify partial differential equations according to linearity as well as distinguish between initial and boundary value problems.
3. Develop essential methods to find solutions of partial differential equations.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Solve physical problems in engineering and biological models and also use the integral transform methods as tools to connect the time domain and frequency domain in signal processing, periodic physical processes etc.,

V. M205T – NUMERICAL ANALYSIS-I

Course Objectives

This course will:

1. Enhance the problem solving skills using an extremely powerful problem solving tool namely numerical methods. The tool is capable of handling large system of equations, non-linearity and complicated geometries that are often impossible to solve analytically.
2. Derive appropriate numerical methods to solve algebraic and transcendental equations, also develop appropriate numerical methods to solve differential equations.
3. Derive appropriate numerical methods to calculate definite integrals and also demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply learnt methods for the analysis, simulation, and design of engineering processes.

VI. M206P – SCILAB PRACTICALS FOR NUMERICAL ANALYSIS-I

Course Objectives

This course will:

1. Help students develop Scilab programs for different numerical methods adopted for solving algebraic equation and system of equations.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.

VII. M207SC – CONTINUUM MECHANICS

Course Objectives

This course will:

1. Introduce essentials of modern Continuum Mechanics by establishing certain classical continuum models within a modern framework.
2. Gives a firm understanding of classical models such as the deformation models and motion models of a continuum.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Utilize equations of continuum mechanic to develop the principles of material as well as spatial frame difference and material, spatial symmetry. In addition, they involve linearization of various types.
3. Attempt to study models which account for a wider array of physical phenomena.

SECOND SEMESTER

PAPER-M 201T: ALGEBRA-II
(4 Hours/week)

Extended Ring Theory (Recapitulation): Rings, Some special classes of rings (Integral domain, division ring, field, maximal and prime ideals). Local ring, The nilradical and Jacobson radical, Operation on ideals, Extension and contraction. The prime spectrum of a ring. Modules Theory: Modules, Sub modules and quotient modules, Module homomorphism, Isomorphism theorems of modules. Direct sums, Free modules, Finitely generated modules, Nakayama Lemma, Simple modules, Exact sequences of modules. Modules with chain conditions - Artinian and Noetherian modules, Modules of finite length, Artinian rings, Noetherian rings, Hilbert basis theorem. **26 Hrs.**

Field Theory: Extension fields, Finite and algebraic extensions. degree of extension, algebraic elements and algebraic extensions, adjunction of an element of a field. Roots of a polynomial, Splitting fields, Construction with straight edge and compass. More about roots (Characteristic of a field), Simple and separable extensions, Finite field**.**
Galois Theory: Elements of Galois Theory, Fixed fields, Normal extension, Galois groups over rationals, degree, distance. **26 Hrs.**

TEXT BOOKS:

1. I.N. Herstein, "Topics in Algebra", Second edition, Vikas Publishing House, 1976.
2. M. F. Atiyah and I. G. Macdonald, "Introduction to Commutative Algebra", Addison, Wesley.

REFERENCE BOOKS:

1. M. Artin, "Algebra", Prentice Hall of India, 1991.
2. N. Jacobson, "Basic Algebra-I", HPC, 1984.
3. C. Musili, "Introduction to Rings and Modules", Narosa Publishing House, 1997.
4. Miles Reid, "Under-graduate Commutative Algebra", Cambridge University Press, 1996.
5. J.B. Fraleigh, "A first courses in Algebra", Third edition, Narosa 1996.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER – M 202T: COMPLEX ANALYSIS

(4 Hours / week)

Analytic functions, Harmonic conjugates, Elementary functions, Mobius Transformation, Conformal mappings, Cauchy's Theorem and Integral formula, Morera's Theorem, Cauchy's Theorem for triangle, rectangle, Cauchy's Theorem in a disk, Zeros of Analytic function. The index of a closed curve, counting of zeros. Principles of analytic Continuation. Liouville's Theorem, Fundamental theorem of algebra. Series, Uniform convergence, Power series, Radius of convergences, Power series representation of Analytic function, Relation between Power series and Analytic function, Taylor's series, Laurent's series. Rational Functions, Singularities, Poles, Classification of singularities, Characterization of removable singularities, poles. Behavior of an Analytic function at an essential singular point. **26 Hrs.**

Entire and Meromorphic functions. The Residue Theorem, Evaluation of definite integrals, Argument principle, Rouche's Theorem, Schwartz lemma, Open mapping and Maximum modulus theorem and applications, Convex functions, Hadamard's Three circle theorem.
Phragmen- Lindelof theorem, The Riemann mapping theorem, Weierstrass factorization theorem. Harmonic functions, Mean Value theorem. Poisson's formula, Poisson's Integral formula, Jensen's formula, Poisson-Jensen's formula. **26 Hrs.**

TEXT BOOKS

1. J. B. Conway, "Functions of one complex variable", Narosa, 1987.
2. L.V. Ahlfors, "Complex Analysis", McGraw-Hill, 1986.

REFERENCE BOOKS

1. E. Hille, "Analytic Theory", Vol. 1, Ginn, 1959.
2. S. Ponnusamy, "Foundations of Complex Analysis", Second Edition, Narosa Publications, 2005.
3. Erwin Kreyszig, "Advanced Engineering Mathematics: Linear Algebra and Complex Analysis", Second edition, Wiley Publications, 2017.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER – M203T: TOPOLOGY_- II
(4 Hours/week)

Compact spaces, Compact sets in the real line, Limit point, Compactness, Sequential compactness and their equivalence for metric spaces. Locally Compact spaces, Compactification, Alexandroff 's one point compactification. The axioms of countability: First axiom space, Second countable space, Separability and the Lindelof property and their equivalence for metric spaces. **13 Hrs.**

The product topology, The metric topology, The quotient topology, Product invariant properties for finite products, Projection maps. Separation axioms: T_0 and T_1 – spaces – definitions and examples, The properties are hereditary and topological. Characterization of T_0 and T_1 – spaces. **13 Hrs.**

T_2- space, Unique limit for convergent sequences, Regularity and the T_3–axiom. Characterisation of regularity, Metric spaces are T_2 and T_3. Complete regularity, Normality and the T_4 – axiom, Metric space is T_4, compact Hausdorff space and regular Lindelof spaces are normal. **13 Hrs.**

Complete regularity, Normality and the T_4 - axiom, Metric space is T_4, compact Hausdorff space and regular Lindelof spaces are normal. Urysohn's Lemma, Tietze's Extension Theorem, Complete normality and the T_5 – axiom. Local fitness, Para compactness, Normality of paracompact space, Metrizability, Urysohn metrization theorem. **13 Hrs.**

TEXT BOOKS

1. J.R. Munkres, "Topology", second edition, Pearson Education, India, 2001.
2. W.J. Pervin, "Foundations of General Topology", Academic Press, 1964.

REFERENCE BOOKS

1. G. F. Simmons, "Introduction to Topology and Modern Analysis", International Edition, McGraw-Hill.
2. G J.L. Kelley, "General Topology", Van Nostrand, Princeton, 1955.
3. J. Dugundji, "Topology", Prentice Hall of India, 1975.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER - M 204T: PARTIAL DIFFERENTIAL EQUATIONS
(4 Hours/week)

Basic definitions, Origin of PDEs, Classification, Geometrical interpretation. The Cauchy problem, The method of characteristics for Semi linear, Quasi linear and non-linear equations, Complete integrals, Examples of equations to analytical dynamics, Discontinuous solution and shockwaves. **13 Hrs.**

Definitions of linear and non- linear equations, Linear Superposition principle, Classification of second-order linear partial differential equations into hyperbolic, parabolic and elliptic PDEs, Reduction to canonical forms, solution of linear homogeneous and non-homogeneous with constant coefficients, Variable coefficients, Monge's method. **13 Hrs.**

Solution of wave equation by the method of separation of variables and integral transforms The Cauchy problem, Wave equation in cylindrical and spherical polar co-ordinates.
Solution of Laplace equation by the method of separation of variables and transforms. Dirichlet's, Neumann's and Churchill's problems, Dirichlet's problem for a rectangle, half plane and circle, Solution of Laplace equation in cylindrical and spherical polar coordinates
13 Hrs.

Fundamental solution of diffusion equation by the method of variables and integral transforms, Duhamel's principle, Solution of the equation in cylindrical and spherical polar coordinates. Solution of boundary value problems by Green's function method for hyperbolic, parabolic and elliptic equations. **13 Hrs.**

TEXT BOOKS

1. I.N. Sneddon, "Elements of PDE's", McGraw Hill Book company Inc., 2006.
2. L. Debnath, "Linear PDE's for Scientists and Engineers", Birkhauser, Boston, 2007.
3. Farlow. John, "Partial differential equations", Springer, 1971.

REFERENCE BOOKS

1. F. Treves, "Basic linear partial differential equations", Academic Press, 1975.
2. M.G. Smith, "Introduction to the theory of partial differential equations", Van Nostrand, 1967.
3. K. Shankara Rao, "Partial Differential Equations", Prentice Hall of India, 2006.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER-M 205T: NUMERICAL ANALYSIS-I

(4 Hours/week)

Examples from algebraic and transcendental equations where analytical methods fail. Examples from system of linear and non-linear algebraic equations where analytical solutions are difficult or impossible. Floating-point number and round-off, absolute and relative errors. **4 Hrs.**

Solution of nonlinear equation in one variable: Fixed point iterative method - convergence and acceleration by Aitken's 2-process. NewtonRaphson methods for multiple roots and their convergence criteria, Ramanujan method, Bairstow's method, Sturm sequence for identifying the number of real roots of the polynomial functions, complex roots-Muller's method. Homotopy and continuation methods. **10 Hrs**.

Solving system of equations: Review of matrix algebra. Gauss-elimination with pivotal strategy. Factorization methods (Crout's, Doolittle and Cholesky). Tri-diagonal systems-Thomas algorithm. Iterative methods: Matrix norms, error analysis and ill-conditioned systems- Jacobi and Gauss-Seidel methods, Chebyshev acceleration. Introduction to steepest descent and conjugate gradient methods. Solutions of nonlinear equations: Newton-Raphson method, Quasi linearization (quasi-Newton's) method, successive over relaxation method. **14 Hrs.**

Interpolation: Review of interpolations basics, Lagrange, Hermite methods and error analyses, Splines-linear, quadratic and cubic (natural, Not a knot and clamped), Bivariate interpolation, Least-squares, Chebyshev and rational approximations. **14 Hrs**.

Numerical integration: Review of integrations. Gaussian Quadrature - Gauss-Legendre, Gauss-Chebyshev, Gauss-Lagaurre, Gauss-Hermite and error analyses, adaptive quadratures, multiple integration with constant and variable limits. **10Hrs.**

TEXT BOOKS

1. S.D. Cante & C de Boor “Elementary numerical analysis”, Tata-McGraw-Hill, 1980.
2. R.L. Burden and J.D. Faires “Numerical Analysis”, Seventh edition, Thomson-Brooks/Cole, 1989.
3. D. Kincade and W Cheney, “Numerical analysis”, Third edition, American Mathematical Society, 2002.

REFERENCE BOOKS.

1. AIserles, “A first course in the numerical analysis of differential equations”, Cambridge texts in applied mathematics, 2008.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER - M 206P: SCILAB PRACTICALS FOR NUMERICAL ANALYSIS-I
(3 Hrs./week)

List of programs:

1. Fixed-point iterative method
2. Newton-Raphson method
3. Newton-Raphson method for multiple roots
4. Mullers method
5. Gauss-elimination method with pivoting
6. Crout's LU Decomposition method.
7. Thomas Algorithm
8. Gauss-Seidel iterative method
9. Conjugate gradient method
10. Cubic Spline interpolation method
11. Gauss-Legendre method
12. Gauss-Chebyshev method
13. Gauss-Hermite method
14. Double integrals

PAPER - M 207SC: CONTINUUM MECHANICS
(3 Hours/week)

Coordinate transformations - Cartesian tensors - Basic properties - Transpose - Symmetric and skew tensors - Isotropic tensors- Deviatoric tensors - Gradient, Divergence and curl in tensor, Calculus of tensors - Integral theorems. **19 Hrs.**

Continuum Hypothesis- Configuration of a continuum - Mass and density - Description of motion - Material and spatial coordinates - Translation - Rotation - Deformation of a surface element -Deformation of a volume element - Isochoric deformation - Examples - Stretch and Rotation- Decomposition of a deformation- Deformation gradient - Strain tensors - Infinitesimal strain - Compatibility relations - Principal strains.
Material and Local time derivatives - Strain-Rate tensor- Transport formulas - Vorticity and circulation - Stream lines Path lines - Examples. **20 Hrs.**

TEXT BOOKS

1. D.S. Chandrasekharaiah & L Debnath, "Continuum Mechanics", Academic Press, 1994.
2. A.J.M. Spencer, "Continuum Mechanics", Longman, 1970.

REFERENCE BOOKS

1. P. Chadwick, "Continuum Mechanics", Allen and Unwin, 1976.
2. L.E. Malvern, "Introduction to the Mechanics of a Continuous Media", Prentice Hall, 1969.
3. Y.C. Fung, "A First course in Continuum Mechanics", Second edition, Prentice Hall, 1977.

Pattern of Question Paper: Five full questions out of eight questions are to be answered.

<u>**III SEMESTER**</u>

I. M301T – LINEAR ALGEBRA

Course Objectives

This course will:

1. Explain the basic arithmetic operations on vectors and matrices, including inversion and determinants, using technology where appropriate and also explain the basic terminology of linear algebra in Euclidean spaces, including linear independence, spanning, basis, rank, nullity, subspace, and linear transformation.
2. Defines projections and orthogonality among Euclidean vectors, including the Gram-Schmidt orthonormalization process and orthogonal matrices.
3. Explain the abstract notions of vector space and inner product space.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Model real-life problems mathematically

II. M302T – FUNCTIONAL ANALYSIS

Course Objectives

The course will:

1. Present the relationships between linear algebraic spaces like Banach and Hilbert spaces.
2. Discuss the importance of algebraic properties relative to working within various metric systems.
3. Develop the ability to form and evaluate conjectures.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply the learnt techniques in the field of signal processing, Mathematical finance – martingale measures, Machine learning etc.,

III. M303T – DIFFERENTIAL GEOMETRY

Course Objectives

This course will:

1. Introduce key concepts and techniques of Differential Geometry and possible topics include surfaces in Euclidean space, general differentiable manifolds, tangent spaces and vector fields and differential forms.
2. Explain the concepts and language of differential geometry and its role in modern mathematics. Analyse and solve complex problems using appropriate techniques from differential geometry.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply problem-solving with differential geometry to diverse situations in physics, engineering, specific research problems or other mathematical contexts

IV. M304T – FLUID MECHANICS

Course Objectives

This course will:

1. Helps to understand basic concept of fluid flow and fluid flow measurements and its applications in many industries including pipe flow, fluid machinery and agitation and mixing etc.
2. Familiarize the students with fluid statics and fluid dynamics.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Know the basic principles of fluid mechanics.
3. Analyze fluid flow problems with the application of the momentum and energy equations, pipe flows as well as fluid machinery.

V. M305T – NUMERICAL ANALYSIS – II

Course Objectives

This course will:

1. Enhance the problem solving skills using an extremely powerful problem solving tools namely numerical methods. All tools are capable of handling large system of equations, non-linearity and complicated geometries that are often impossible to solve analytically.
2. Derive appropriate numerical methods to solve ODE and PDE

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply learnt methods for the analysis, simulation, and design of engineering processes.

VI. M306P – SCILAB PRACTICALS FOR NUMERICAL ANALYSIS – II

Course Objectives

This course will:

1. Help students develop Scilab programs for different numerical methods adopted for solving ODE and PDE equations.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.

THIRD SEMESTER

PAPER – M301T: LINEAR ALGEBRA
(4 Hours / week)

Recapitulation: Vector Spaces, Subspaces, Linear Combinations and Systems of Linear Equations, Linear dependence and independence, Basis and Dimension, Maximal linearly independence subsets, Direct sums, Linear transformation, Linear Operators.

Algebra of Linear transformations, Minimal polynomials, Regular and singular transformation, Range and rank of a transformation and its properties, characteristic roots and characteristic vectors.

The matrix representation of a linear transformation, Composition of a linear transformation and matrix multiplication, The change of coordinate matrix, transition matrix, The dual space.

Characteristic polynomials, Diagonalizability, Invariant subspaces, Cayley-Hamilton theorem. **26 Hrs.**

Canonical Forms: Triangular canonical form, Nilpotent transformations, Jordan canonical form, The rational canonical form.

Inner Product Spaces, Orthogonal complements, Gram-Schmidt Orthonormalization process.

Positive Definite Matrices, Maxima, minima and saddle points, Tests for positive definiteness, Singular Value Decomposition and its applications.

Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, rank and signature, Sylvester's law of inertia. **26 Hrs.**

TEXT BOOKS

1. K. Hoffman and R. Kunze, "Linear Algebra", Pearson Education, India, 2003. Prentice-Hall of India, 1991.
2. I. N. Herstein, "Topics in Algebra", Second edition, John Wiley & Sons, 2006.
3. G. Strang, "Linear Algebra and its Applications", Third edition, Brooks/Cole Ltd., New Delhi, 2003.
4. J. Gilbert and L. Gilbert, "Linear Algebra and Matrix theory", Academic Press, 1995.

REFERENCE BOOKS

1. S. Lang, "Linear Algebra", Springer-Verlag, New York, 1989.
2. M. Artin, "Algebra", Prentice Hall of India, 1994.
3. S. Freidberg A Insel, and L Spence, "Linear Algebra", Fourth Edition, Prentice Hall of India, 2009.
4. L. Hogben, "Handbook of Linear Algebra", Chapman and Hall CRC, 2006.

Pattern of Question Paper: Five full questions out of eight questions are to be answered.

PAPER – M302T: FUNCTIONAL ANALYSIS
(4 Hours / week)

Normed linear spaces. Banach Spaces: Definition and Examples. Quotient Spaces. Convexity of the closed unit sphere of a Banach Space. Examples of normed linear spaces which are not Banach. Holder's inequality. Minkowski's inequality. Linear transformations on a normed linear space and characterization of continuity of such transformations. The set $B\ (N,\ N')$ of all bounded linear transformations of a normed linear space N into normed linear space N′. Linear functionals, The conjugate space N*. The natural imbedding of N into N**. Reflexive spaces.
13 Hrs.

Hahn-Banach theorem and its consequences, Projections on a Banach space. The open mapping theorem and the closed graph theorem. The uniform boundedness theorem. The conjugate of an operator, Properties of conjugate operators. **13 Hrs.**

Inner product spaces, Hilbert spaces: Definition and Examples, Schwarz's inequality. Parallelogram Law, Polarization identity. Convex sets, a closed convex subset of a Hilbert space contains a unique vector of the smallest norm. Orthogonal sets in a Hilbert space. Bessel's inequality. Orthogonal complements, complete orthonormal sets, Orthogonal decomposition of a Hilbert space. Characterization of complete orthonormal set. Gram-Schmidt orthogonalization process. **13 Hrs.**

The conjugate space H* of a Hilbert space H. Representation of a functional f as f(x) = (x, y) with y unique. The Hilbert space H*. Interpretation of T* as an operator on H. The adjoint operator T* on B(H). Self-adjoint operators, Positive operators. Normal operators. Unitary operators and their properties. Projections on a Hilbert space. Invariant subspace. Orthogonality of projections. Eigen values and Eigen space of an operator on a Hilbert space. Spectrum of an operator on a finite dimensional Hilbert space. Finite dimensional spectral theorem.
13 Hrs.

TEXT BOOKS

1. G. F. Simmons, "Introduction to Topology and Modern Analysis", Intl. edition, McGraw- Hill, 1998.
2. B. V. Limaye, "Functional Analysis", Wiley Eastern, 1998.

REFERENCE BOOKS

1. G. Bachman and L. Narici "Functional Analysis", Academic, 2006.
2. Gupta and Gupta, "Measure Theory and Functional Analysis", Twenty third edition, Krishna Prakash Media (P) Ltd., India, 2011.
3. P.R. Halmos, "Finite dimensional vector paces", Van Nostrand, 1958.
4. E. Kreyszig, "Introduction to Functional Analysis with Applications", John Wiley & Sons, 2000.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER – M 303T: DIFFERENTIAL GEOMETRY
(4 Hours/week)

Calculus on Euclidean Space: Euclidean space. Natural coordinate functions. Differentiable functions. Tangent vectors and tangent spaces. Vector fields. Directional derivatives and their properties. Curves in $\mathbb{E}^3$.Velocity and speed of a curve. Reparametrization of a curve. 1-forms and Differential forms. Wedge product of forms. Mappings of Euclidean spaces. Derivative map. **13 Hrs.**

Frame Fields: Arc length parametrization of curves. Vector field along a curve. Tangent vector field, Normal vector field and Binormal vector field. Curvature and torsion of a curve. The Frenet formulas, Frenet approximation of unit speed curve and Geometrical interpretation. Properties of plane curves and spherical curves. Arbitrary speed curves. Cylindrical helix, Covariant derivatives and covariant differentials. Cylindrical and spherical frame fields, Connection forms. Attitude matrix. Structural equations. Isometries of $\mathbb{E}^3$- Translation, Rotation and orthogonal transformation. The derivative map of an isometry. **13 Hrs.**

Calculus on a Surface: Coordinate patch. Monge patch. Surface in $\mathbb{E}^3$.Special surfaces- sphere, cylinder and surface of revolution. Parameter curves, velocity vectors of parameter curves, Patch computation. Parametrization of surfaces- cylinder, surface of revolution and torus. Tangent vectors, vector fields and curves on a surface in $\mathbb{E}^3$. Directional derivative of a function on a surface of $\mathbb{E}^3$. Differential forms and exterior derivative of forms on surface of $\mathbb{E}^3$. Pull back functions on surfaces of $\mathbb{E}^3$. **13 Hrs.**

Shape Operators: Definition of shape operator. Shape operators of sphere, plane, cylinder and saddle surface. Normal curvature, Normal section. Principal curvature and principal direction. Umbilic points of a surface in $\mathbb{E}^3$. Euler's formula for normal curvature of a surface in $\mathbb{E}^3$. Gaussian curvature, Mean curvature and Computational techniques for these curvatures. Minimal surfaces. Special curves in a surface of $\mathbb{E}^3$-
Principal curve, geodesic curve and asymptotic curves. Special surface - Surface of revolution.
13 Hrs.

TEXT BOOKS

1. Barrett O'Neil, "Elementary Differential Geometry", Academic Press, New York and London, 1966.
2. T.J. Willmore, "An introduction to Differential Geometry", Clarendon Press, Oxford, 1959.

REFERENCE BOOKS

1. D.J. Struik, "Lectures on Classical Differential Geometry", Addison Wesley, Reading, Massachusetts, 1961.
2. Nirmala Prakash, "Differential Geometry- an integrated approach", Tata McGraw-Hill, New Delhi, 1981.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER-M 304T: FLUID MECHANICS
(4 Hours/week)

Motion of inviscid fluids: - Recapitulation of equation of motion and standard results - Vortex motion - Helmholtz vorticity equation - Permanence of vorticity and circulation - Kelvin's minimum energy theorem – Impulsive motion - Dimensional analysis – Non-dimensional numbers. **7 Hrs.**

Two dimensional flows of inviscid fluids: Meaning of two-dimensional flow - Stream function – Complex potential - Line sources and sinks - Line doublets and vortices - Images - Milne-Thomson circle theorem and applications - Blasius theorem and applications. **12 Hrs.**

Motion of Viscous fluids: Stress tensor – Navier-Stokes equation - Energy equation - Simple exact solutions of Navier-Stokes equation: (i) Plane Poiseuille and Hagen-Poiseuille flows. (ii) Generalized plane Couette flow. (iii) Steady flow between two rotating concentric circular cylinders. (iv) Stokes's first and second problems. (v)Slow and steady flow past a rigid sphere and cylinder. Diffusion of vorticity - Energy dissipation due to viscosity. Boundary layer concept- Derivation of Prandtl boundary layer equations -Blasius solution -Karman's integral equation. **19 Hrs.**

Gas Dynamics: Compressible fluid flows -Standard forms of equations of state -Speed of sound in gas-Equations of motion of non-viscous and viscous compressible flows. Subsonic, Sonic and supersonic flows -Isentropic flows - Gas dynamical equations. **7 Hrs.**

Turbulent Flow: Introduction-Transition from laminar to turbulent flow-Homogeneous turbulence- Isotropic turbulence-Spatial, Time and ensemble averages-Basic properties of averages-Reynolds averaging procedure-Derivation of turbulent equations using Reynolds averaging procedure with gradient-diffusion i,e., K-model for closure. **7 Hrs**.

TEXT BOOKS

1. S. W. Yuan, "Foundations of Fluid Mechanics", Prentice Hall, 1976.
2. F Chortlen, "Fluid Dynamics", First edition, CBS Publishers and Distributers, 1985.
3. R K Rathy, "An introduction to fluid dynamics", Oxford and IBH, 1976.
4. C.S. Yih, "Fluid Mechanics", McGraw-Hill, 1969.

REFERENCE BOOKS

1. Pijush K. Kundu, Ira M. Cohen and David R. Dowling, "Fluid Mechanics", Fifth edition, 2010.
2. C.S. Yih, "Fluid Mechanics", McGraw-Hill, 1969.
3. G.K. Batchelor, "An Introduction to Fluid Dynamics", 2000.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER-M 305T: NUMERICAL ANALYSIS-II
(4 Hours/week)

Examples from ODE where analytical solution are difficult or impossible. Examples from PDE where analytical solution are difficult or impossible.

Numerical solution of ordinary differential equations: Initial value problems: Picard's and Taylor series methods. Euler's and Modified Euler's methods, Runge-Kutta methods of second and fourth order, Runge-Kutta-Fehlberg methods.

Multistep methods - the Adams-Bashforth and Adams-Moulton predictor-corrector methods. Local and global errors, stability analyses for the above methods. Methods for systems and higher order differential equations. Boundary value problems: Shooting methods, Cubic spline methods and finite difference method. **26 Hrs.**

Numerical solution of partial differential equations: Elliptic equations: Difference schemes for Laplace and Poisson's equations. Parabolic equations: Difference methods for one-dimension– methods of Schmidt, Laasonen, Dufort-Frankel and Crank-Nicolson. Alternating direction implicit method for two-dimensional equation.

Hyperbolic equations: Difference methods for one-dimension- explicit and implicit schemes, D'Yakonov split and Lees alternating direction implicit methods for two-dimensional equations. Stability and convergence analyses for the above equations. **26 Hrs.**

TEXT BOOKS

1. M.K. Jain, "Numerical solution of differential equations", Second edition, Wiley Eastern, 1979.
2. R.L. Burden and JD Faires, "Numerical Analysis", Seventh edition, Thomson-Brooks/Cole, 1989.
3. S. Larsson and V. Thomee, "Partial differential equations with numerical methods", First edition, Springer, 2008.
4. J.W. Thomas, "Numerical partial differential equations: finite difference methods", Second edition, Springer, 1998.

REFERENCE BOOKS

1. D. Kincade and W. Cheney, "Numerical analysis", Third edition, American Mathematical Society, 2002.
2. A. Iserles, "A first course in the numerical analysis of differential equations", Second edition, Cambridge texts in applied mathematics, 2008.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER M306P: SCILAB PRACTICALS FOR NUMERICAL ANALYSIS II

(3 Hours/week)

List of programs

1. Euler's method and Modified Euler's method
2. Runge - Kutta 2 and 4 order methods
3. Runge - Kutta- Fehlberg order method
4. Runge - Kutta for system of equations
5. Adam's Predictor-corrector method
6. Finite difference methods
7. Shooting methods
8. Laplace equation
9. Poisson equation
10. Schmidt Method
11. Crank-Nicolson method
12. ADI method
13. Explicit method for wave equation
14. Lees ADI method for wave equation

PAPER M307OE: OPERATIONS RESEARCH

(2 Hours/week)

Operations research: Development, Advantages, Disadvantages of operations research. Definition of Linear Programming Problem (L.P.P.) - Formulation and graphical solutions of L.P.P. - Simplex method - Dual simplex method.

8 Hrs.

Introduction to Transportation Problem - Initial Basic Feasible solution - Moving towards Optimality - Degeneracy in Transportation Problems - Unbalanced Transportation Problem - Assignment Problem **10 Hrs.**

Games and Strategies - Introduction - Two person zero sum games – Maxi-Min and Mini-Max Principles - Games without saddle point - Solution of 2 x 2 rectangular games, conversion of game problem into LPP . **8 Hrs.**

TEXTBOOKS:

1. Hamdy A Taha, "Operations Research", Prentice Hall of India, 1995.
2. A. Mukherjee, N.K. Bej, "Advanced Linear Programming and Game Theory", Books and Allied (P) Ltd, 2013.

REFERENCE BOOKS:

1. Kanti Swarup, P K Gupta, "Operations Research", Man Mohan, Sultan Chand & Sons, 1995.
2. G Hadley, "Linear Programming", Narosa Publishing House, 2002.
3. K. V. Mittal and C. Mohan, "Optimization Methods in Operation Research and System Analysis", New Age Publishers, 1996.

Pattern of Question Paper: Five full questions out of eight are to be answered.

IV SEMESTER

I. M401T – MEASURE AND INTEGRATION

Course Objectives

This course will:

1. Introduce abstract measure on the real line and in n-dimensional Euclidean space.
2. Explain basic and advanced directions of the theory.
3. Helps learn integration with respect to any measure and Lebesgue integration also related results.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Use the leant methods to study quantum theory, stochastic calculus, Harmonic analysis, probability and statistics etc…

II. M402T- MATHEMATICAL METHODS

Course Objectives

This course will:

1. Introduce integral equations and integral transforms and perturbation techniques.
2. Emphasizes the role of Volterraand Fredholm equations as unifying tools in the study of functional equations, presents the relation between abstract Volterra, Fredholm equations and other types of functional-differential equations.

Course Outcomes

Students will be able to:

1. Demonstrate all objectives practically.
2. Know the use of Laplace transform and Fourier transforms in system modelling, digital signal processing, process control, solving Boundary Value Problems. Also apply the technique of perturbations in several nonlinear optimal control problems.

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III. M403T(A) – GRAPH THEORY

Course Objectives

This course will:

1. Cover a variety of different problems in directed/undirected graph, connectivity, connected components, subgraph, in family of graphs like clique, independent set, planar graphs, graph colouring, stable matching and factorization.

Course Outcomes

Students will be able to:

1. Demonstrate all objectives practically.
2. After the course the student will have a strong background of graph theory which has diverse applications in the areas of computer science, biology, chemistry, physics, sociology, and engineering.

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IV. M403T(B) – MAGNETOHYDRODYNAMICS

Course Objectives

This course will:

1. Introduce fundamental concepts like magnetic field inducing current in moving conductive fluid, polarization of fluid etc.,
2. Studies the set of equations that describe MHD which are a combination of Navier – Stokes equation and Maxwell's equations.

Course Outcomes

Students will be able to:

1. Demonstrate all objectives practically.
2. Apply all the learnt phenomena in fields of Geophysics, Astrophysics, build sensors, Engineering, Magnetic drug targeting etc…

V. M403T(C) – FINITE ELEMENT METHODS WITH APPLICATIONS

Course Objectives

This course will:

1. Introduce the mathematical concepts to obtain approximate solutions of ODE and PDE.
2. Discuss the range of problems that arise in the analysis of economic data and the methods available to address these problems.
3. Discuss modelling complex geometrical problems and solution techniques.

Course Outcomes

Students will be able to:

1. Demonstrate all course objectives practically.
2. Apply FEM for structural applications using truss, beam, frame and plane elements. Also solve and interpret results to realistic engineering problems through the use of a major commercial general purpose as in petroleum industry.

VI. PROJECT WORK

Course Objectives

This course will:

1. Train students to find solutions to on real life challenging problems in many interdisciplinary fields.
2. Introduce students to the research environment.

Course Outcomes

Students will be able to:

1. Apply all learnt mathematical techniques to solve problems in real life.
2. Conduct valuable research in different fields of Mathematics that suits his/her interests.

FOURTH SEMESTER

PAPER- M 401T: MEASURE AND INTEGRATION

(4 Hours/week)

Algebra of sets, sigma algebras, open subsets of the real line. F_σ and G_δ sets, Borel sets, Outer measure of a subset of $\mathbb{R}$, Lebesgue outer measure of a subset of $\mathbb{R}$ Existence, non-negativity and monotonicity of Lebesgue outer measure; Relation between Lebesgue outer measure and length of an interval; Countable sub additivity of Lebesgue outer measure, Translation invariance**.** (Lebesgue) measurable sets, (Lebesgue) measure, Complement, union, intersection and difference of measurable sets, Denumerable union and intersection of measurable sets; Countable additivity of measure, The class of measurable sets as algebra, The measure of the intersection of a decreasing sequence of measurable sets. **13 Hrs.**

Measurable functions; Scalar multiple, sum, difference and product of measurable functions. Measurability of a continuous function and measurability of a continuous image of measurable function. Convergence pointwise and convergence in measures of a sequence of measurable functions. **13 Hrs.**

Lebesgue Integral; Characteristic function of a set; simple function; Lebesgue integral of a simple function; Lebesgue integral of a bounded measurable function; Lebesgue integral and Riemann integral of a bounded function defined on a closed interval; Properties of Lebesgue integral for bounded measurable function; The bounded convergence theorem; Lebesgue integral of a non-negative function; Fatou's lemma; Monotone Convergence theorem; Lebesgue integral; Properties of Lebesgue integral; Lebesgue Dominated Convergence theorem . **13 Hrs.**

Differentiation of monotone functions. Vitali covering lemma. Functions of bounded variation. Differentiability of an integral. Absolute continuity and indefinite integrals. Lp spaces. Holder and Minkowski inequalities. Convergence and completeness, Bounded linear functional. **13 Hrs.**

TEXT BOOKS

1. H.L. Royden, "Real Analysis", Macmillan, 1963.
2. P.K. Jain and V.P. Gupta, "Lebesgue Measure &Integration", New Age International, 2011.

REFERENCE BOOKS

1. P.R. Halmos, "Measure Theory", East West Press, 1962.
2. W. Rudin, "Real & Complex Analysis", McGraw-Hill, 1966.
3. Gupta and Gupta, "Measure Theory and Functional Analysis", Twenty third edition, Krishna Prakash Media (P) Ltd., India, 2011.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER- M 402T: MATHEMATICAL METHODS
(4 Hours/week)

Integral Transforms: General definition of Integral transforms, Kernels, etc. Development of Fourier integral, Fourier transforms – inversion, Illustration on the use of integral transforms, Laplace, Fourier, Hankel and Mellin transforms to solve ODEs and PDEs - typical examples. Discrete orthogonality and Discrete Fourier transform. Wavelets with examples, Wavelet transforms. **13 Hrs.**

Integral Equations: Definition, Volterra and Fredholm integral equations. Solution by separable kernel, Neumann's series resolvent kernel and transform methods, Convergence for Fredholm and Volterra types. Reduction of IVPs BVPs and Eigen value problems to integral equations. **13 Hrs.**

Asymptotic expansions: Asymptotic expansion of functions, power series as asymptotic series, Asymptotic forms for large and small variables. Uniqueness properties and Operations. Asymptotic expansions of integrals, Method of integration by parts (include examples where the method fails), Laplace's method and Watson's lemma, Method of stationary phase and steepest descent. **13 Hrs.**

Regular and singular perturbation methods: Parameter and co-ordinate perturbations. Regular perturbation solution of first and second order differential equations involving constant and variable coefficients. Include Duffings equation, Vanderpol oscillator, Small Reynolds number flow. Singular perturbation problems, Matched asymptotic expansions, Simple examples. Linear equation with variable coefficients and nonlinear BVP's. Problems involving Boundary layers. Poincare – Lindstedt method periodic solution. WKB method, Turning points, zeroth order Bessel function for large arguments, solution about irregular singular points. **13 Hrs.**

TEXT BOOKS

1. I.N. Sneddon, "The use of Integral Transforms", Tata McGraw-Hill, Publishing Company Ltd, New Delhi, 1974.
2. R. P. Kanwal, "Linear integral equations theory and techniques", Academic Press, New York, 1971.
3. C.M. Bender and S.A. Orszag, "Advanced mathematical methods for scientists and engineers", McGraw-Hill, New York, 1978.

REFERENCE BOOKS

1. H.T. Davis, "Introduction to nonlinear differential and integral equations", Dover Publications, 1962.
2. A.H. Nayfeh, "Perturbation Methods", John Wiley & sons New York, 1973.
3. Don Hong, J. Wang and R. Gardner, "Real analysis with introduction to wavelets and applications", Academic Press Elsevier, 2006.
4. R.V. Churchill, "Operational Mathematics", McGraw-Hill, New York, 1958.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER - M 403T (A) : GRAPH THEORY

(4 Hrs./week)

Connectivity: Cut-vertex, Bridge, Blocks, Vertex-connectivity, Edge-connectivity and some external problems, Mengers theorems, properties of n-connected graphs with respect to vertices and edges. Planarity: Plane and Planar graphs, Euler Identity, Non planar graphs, Maximal planar graph Outer planar graphs, Maximal outer planar graphs, Characterization of planar graphs, Geometric dual, Crossing number. **13 Hrs.**

Colorability: Vertex coloring, Color class, n-coloring, Chromatic index of a graph, Chromatic number of standard graphs, Bichromatic graphs, Colorings in critical graphs, Relation between chromatic number and clique number/independence number/maximum degree, Edge coloring, Edge chromatic number of standard graphs. Coloring of a plane map, Four color problem, Five color theorem, Uniquely colorable graph. Chromatic polynomial. **13 Hrs.**

Matchings and factorization: Matching- perfect matching, augmenting paths, maximum matching, Hall's theorem for bipartite graphs, the personnel assignment problem, a matching algorithm for bipartite graphs, Factorizations, 1-factorization, 2-factorization. Partitions-degree sequence, Havel's and Hakimi algorithms and graphical related problems. **13 Hrs.**

Directed Graphs: Preliminaries of digraph, Oriented graph, indegree and outdegree, Elementary theorems in digraph, Types of digraph, Tournament, Cyclic and transitive tournament, Spanning path in a tournament, Tournament with a Hamiltonian path, strongly connected tournaments. Domination concepts and other variants: Dominating sets in graphs, domination number of standard graphs, Minimal dominating set, Bounds of domination number in terms of size, order, degree, diameter, covering and independence number, domatic number, domatic number of standard graphs. **13 Hrs.**

TEXT BOOKS

1. F. Harary, "Graph Theory", Addison -Wesley, 1969.
2. G. Chartrand and Ping Zhang, "Introduction to Graph Theory". McGraw-Hill, International edition, 2005.
3. J. A. Bondy and V.S.R. Murthy, "Graph Theory with Applications", Macmillan, London, 2004.

REFERENCE BOOKS

1. D.B. West, "Introduction to Graph Theory", Second edition, Pearson Education Asia, 2002.
2. Charatrand and L. Lesnaik-Foster, "Graph and Digraphs", Third edition, CRC Press, 2010.
3. T.W. Haynes, S.T. Hedetneime and P. J. Slater, "Fundamental of domination in graphs", Marcel Dekker. Inc., New York.1998.

4. J. Gross and J. Yellen, "Graph Theory and its application", CRC Press LLC, Boca Raton, Florida, 2000.
5. N. Deo, "Graph Theory", Prentice Hall of India Pvt. Ltd, New Delhi – 1990.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER- M 403T(B) : MAGNETOHYDRODYNAMICS
(4 Hours/week)

Electrodynamics: Electrostatics and electromagnetic units –Derivation of Gauss law -Faraday's law- Ampere's law and solenoidal property-–Conservation of charges -Electromagnetic boundary conditions. Dielectric materials. **12 Hrs.**
Basic Equations**:** Derivation of basic equations of MHD - MHD approximations -Non-dimensional numbers – Boundary conditions on velocity, temperature and magnetic. **8 Hrs.**

Classical MHD: Alfven's theorem- Frozen-in-phenomenon-illustrative examples -Kelvin's circulation theorem-Bernoulli's equations-Analogue of Helmholtz vorticity equation-Ferraro's law of isorotation. **6 Hrs.**

Magnetostatics: Force free magnetic field and important results thereon-illustrative examples on abnormality parameter -Chandrasekhar's theorem -Bennett pinch and instabilities associated with it. **7 Hrs.**
Alfven waves: Lorentz force as a sum of two surface forces- cause for Alfven waves-applications -Alfven wave equations in incompressible fluids- equipartition of energy–experiments on Alfven waves- dispersion relations- Alfven waves in compressible fluids- slow and fast waves -Hodographs. **12 Hrs.**

Flow Problems: Hartmann flow- Hartmann –Couette flow- Temperature distribution for these flows. **7 Hrs.**

TEXT BOOKS:
1. T.G. Cowling, "Magnetohydrodynamics", Interscience, 1957.
2. V.C.A .Ferraro and C. Plumpton, "An Introduction to Magneto-Fluid Mechanics", Oxford University Press, 1961.
3. G.W. Sutton and A. Sherman, "Engineering Magnetohydrodynamics", McGraw-Hill, 1965.
4. Alan Jeffrey, "Magnetohydrodynamics", Oliver & Boyd, 1966.
5. K.R. Cramer and S.I. Pai, "Magneto fluid Dynamics for Engineers and Applied Physicists", Scripta Publishing Company, 1973.
6. R K Rathy, "An introduction to fluid dynamics", Oxford and IBH, 1976.

REFERENCE BOOKS:
1. D.J. Griffiths, "Introduction to Electrohydrodynamics", Prentice Hall, 1997.

2. P.H. Roberts, "An Introduction to Magnetohydrodynamics", Longman, 1967.
3. H.K. Moffat, "Magnetic field generation in electrically conducting fluids", Cambridge University Press, 1978.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**

PAPER- M 403T(C): FINITE ELEMENT METHODS WITH APPLICATIONS
(4 Hours/week)

Weighted Residual Approximations: - Point collocation, Galerkin and Least Squares method. Use of trial functions to the solution of differential equations.

Finite elements: One dimensional and two dimensional basis functions, Lagrange and serendipity family elements for quadrilaterals and triangular shapes. Isoparametric coordinate transformation. Area coordinates standard 2- squares and unit triangles in natural coordinates.

26 Hrs.

Finite element Procedures: - Finite element formulations for the solutions of ordinary and partial differential equations: Calculation of element matrices, assembly and solution of linear equations.

Finite Element solution of one dimensional ordinary differential equations, Laplace and Poisson equations over rectangular and non-rectangular and curved domains. Applications to some problems in linear elasticity: Torsion of shafts of square, elliptic and triangular cross sections. **26 Hrs.**

TEXT BOOKS

1. O.C. Zienkiewiez and K. Morgan, "Finite Elements and approximation", John Wieley, 1983.
2. P.E. Lewis and J.P. Ward, "The Finite element method- Principles and applications", Addison Weley, 1991.
3. L.J. Segerlind, "Applied finite element analysis", Second edition, John Wiley, 1984.
4. J.N. Reddy, "An Introduction to Finite Element Method", Third edition, McGraw-Hill, 2006.

REFERENCE BOOKS:

1. O.C. Zienkiewicz and R.L. Taylor, "The finite element method Vol.1 Basic formulation and Linear problems", Fourth edition, New York, McGraw-Hill, 1989.

2. J.N. Reddy, "An introduction to finite element method", New York, McGraw-Hill, 1984.
3. D.W. Pepper and J.C. Heinrich, "The finite element method, Basic concepts and applications, Hemisphere", Publishing Corporation, Washington, 1992.
4. S.S. Rao, "The finite element method in Engineering", Second edition, Oxford, Pergamon Press, 1989.

5. D. V. Hutton, "Fundamental of Finite Element Analysis", 2004.
6. E. G. Thomson, "Introduction to Finite Elements Method", Theory Programming and applications, Wiley Student Edition, 2005.

Pattern of Question Paper: Five full questions out of eight are to be answered.

PAPER M-403T (D): COMPUTATIONAL FLUID DYNAMICS (CFD)
(4 Hours/week)

Review of partial differential equations, numerical analysis, fluid mechanics. **4 Hrs.**

Finite Difference Methods: Derivation of finite difference methods, finite difference method to parabolic, hyperbolic and elliptic equations, finite difference method to nonlinear equations, coordinate transformation for arbitrary geometry, Central schemes with combined space-time discretization -Lax-Friedrichs, Lax-Wendroff, MacCormack methods, Artificial compressibility method, pressure correction method
– Lubrication model, Convection dominated flows – Euler equation – Quasilinearization of Euler equation, Compatibility relations, nonlinear Burger equation. **18 Hrs.**

Finite Volume Methods: General introduction, Node-centered-control volume, Cell-centered-control volume and average volume, Cell-Centred scheme, Cell-Vertex scheme, Structured and Unstructured FVMs, Second and Fourth order approximations to the convection and diffusion equations (One and Two-dimensional examples). **12 Hrs.**

Finite Element Methods: Introduction to finite element methods, one-and two-dimensional bases functions – Lagrange and Hermite polynomials elements, triangular and rectangular elements, Finite element method for one-dimensional problem: model boundary value problems, discretization of the domain, derivation of elemental equations and their connectivity, composition of boundary conditions and solutions of the algebraic equations. Finite element method for two-dimensional problems: model equations, discretization, interpolation functions, evaluation of element matrices and vectors and their assemblage. **18 Hrs.**

TEXT BOOKS
1. T. J. Chung, "Computational Fluid Dynamics", Cambridge Univ. Press, 2003.
2. J Blazek, "Computational Fluid Dynamics", Elsevier, 2001.
3. Harvard Lomax, Thomas H. Pulliam, David W Zingg, "Fundamentals of Computational Fluid Dynamics", NASA Report, 2006.

REFERENCE BOOKS
1. C.A J. Fletcher, "Computational techniques for Fluid Dynamics", Vol. 1 & 2, Springer Verlag 1991.

Pattern of Question Paper: Five full questions out of eight are to answered.

PAPER- M 403T(E): MATHEMATICAL MODELING AND SIMULATION
(4 Hours/week)

Concept of mathematical modeling and simulation: Definition, Classification, Characteristics and limitations of modeling and simulation. Models leading to ordinary differential equations: Setting up of first order differential equations from real world problems - Qualitative solution and sketching for first-order differential equations - Difference & differential equation models and simulation for population Growth - Growth and Decay Models - single species population models - Spread of Technological innovations - Higher order linear models- spring and dashpot systems - electrical circuit equation - Model for detection of diabetes - Mixing processes - Non-linear system of equations - Combat models - Predator-prey equation, Qualitative theory of differential equation - Interacting species - Spread of epidemics, Modeling linear systems by frequency response methods.
Models and their simulation leading to linear and nonlinear partial differential equations: Simple models, Conservation law - Traffic flow on highway - Flood waves in rivers - Glacier flow, roll waves and stability, Shallow water waves- Convection diffusion - processes Burger's equation, Convection - reaction processes - Fisher's equation. Telegrapher's equation of heat transfer in a layered solid. Chromatographic models sediment transport in rivers.

26 Hrs.

Modeling of ground water flow: Porous media -Aquifers-Porosity-Permeability and Averages-Derivations od Darcy and Darcy equations. Basic ground water flow using Darcy model. Dam seepage. Dupuit approximation. Subsurface low with similarity solutions.

Air pollution: Background-Origin-Atmospheric composition- Sources of air pollution, primary and secondary air pollutant, effects of air pollution. Mathematical principles of air pollution using gradient diffusion model conservation of mass, momentum and species/ turbulent flow in the atmosphere. Mixture of SPM and atmospheric fluid. Dispersion of SPM-Aerosols.

Modeling in Biomechanics: Fundamental concepts of biomechanics. Mathematical modeling and simulation of Haemolysis, Synovial joints and Coronary Artery Disease (Mainly based on dispersion phenomenon). **26 Hrs.**

TEXT BOOKS:

1. M. Braun, C.S. Coleman and DA. Drew, "Differential Equation Models", Springer Verlag, 1978.
2. Lokenath Debnath, "Nonlinear partial differential equations", Hillhauser, Boston, 1997.

REFERENCE BOOKS:

1. Neil Gerschenfeld, "The nature of Mathematical Modeling", Cambridge University Press, 1999.
2. A.C. Fowler,"Mathematical Models in Applied Sciences", Cambridge University Press, 1997.

Pattern of Question Paper: Five full questions out of eight are to be answered**.**