DAVANGERE UNIVERSITY

SHIVAGANGOTHRI – 577 007, DAVANGERE, INDIA.

SYLLABUS
FOR

MASTER OF SCIENCE (M. SC.)
SEMESTER SCHEME - CBCS

MATHEMATICS

.

With effect from 2020-21 & onwards

DAVANGERE UNIVERSITY

Shivagangotri, Davangere-577 007

Department of Mathematics

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Professor & Chairman

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Ref. No. DU-MAT-2019-20/ 138

Date: 17-02-2020

Board of Studies meeting in P.G. Mathematics

The meeting of Board of Studies in PG Mathematics was held in the Chamber of Chairman, Department of Mathematics, Davangere University, Davangere on 17th February, 2020 at 10.30 am and discussed the following:

Proceedings

Item No. 1: To Read and Confirm the minutes of the last meeting.
Resolution No. 1: Read and confirm the minutes of the last meeting held on 06th February, 2019.

Item No. 2: Upgradation of panel of Examiners for PG Mathematics Examination of 2020-21 & onwards.

Resolution No. 2: Board has prepared the list of panel of examiners for PG Mathematics examination of 2020-21 & onwards. And, resolved to approve and recommend the same to the University (see Appendix - I).

Item No. 3: Approval of Ph. D., synopsis of the Ph. D., Candidates seeking admission to Ph. D., Programme in Mathematics for the academic year 2019-20.

Resolution No. 3: The Board thoroughly goes through the synopsis submitted by the Ph. D., candidates. Further, by taking the consideration of the recommendations of Doctoral committee meeting held on 14th January, 2020, it is resolved to approve the synopsis for the Ph. D., admission to the Ph. D., candidate and recommend the same to the University for provisional registration (see Appendix - II).

Item No. 4: Preparation of Syllabus of the Ph. D., course work for Ph. D., Programme in Mathematics.

Resolution No. 4: Board has prepared the syllabus for Ph. D., course work in Mathematics along with the examination pattern and resolved to approve and recommend the same to the University for further needful action (see Appendix - III).

17/2/2020

Chairman
Department of Mathematics
Davangere University
Shivagangotri, Davangere-577 007

17/02/2020.

Item No. 5: Preparation of Syllabus of the M. Phil., Programme in Mathematics.

Resolution No. 5: Board has prepared the syllabus for M.Phil., Programme in Mathematics along with the examination pattern and resolved to approve and recommend the same to the University for further needful action (see Appendix - IV).

Item No. 6: Preparation of Syllabus of the PG Course in Mathematics.

Resolution No. 6: Board thoroughly goes through the syllabus of UGC/CSIR-NET Examination, K-SET Examination and also various reputed Universities. Further, prepared the syllabus for P.G. Course in Mathematics on far with UGC recommended syllabus along with the examination pattern. And, resolved to approve and recommend the same syllabus to the University for P.G. Mathematics Course with effect from the academic year 2020-21 onwards (see Appendix - V).

Item No. 7: Any other matter with the permission of the Chair

Resolution No. 7: No matter.

The following members were present:

Chairman and Members in the Board of Studies		Signature
Prof. U. S. Mahabaleshwar	Chairman (BOS)	....
Prof. Soner Nanadappa D.	External Member (P .G.)	....
Dr. D. G. Prakasha	Internal Member (P.G.)	....
Dr. B. C. Prasannakumara	Internal Member (P.G.)	....
Mr. Mahesh Barki	Internal Member (P.G.)	....

17/2/2020

U.S.MAHABALESHWAR
Chairman-B.O.S.
Department of Mathematics,
Davangere University, Davangere.

Chairman
Department of Mathematics
Davangere University
Shivagangotri, Davangere - 577 007

PROGRAM OBJECTIVE

The M.Sc. program in Mathematics aims at developing mathematical ability in students with acute and abstract reasoning. The course will enable students to cultivate a mathematician's habit of thought and reasoning and will enlighten students with mathematical ideas relevant for oneself and for the program itself.

PROGRAMME OUTCOMES (POs)

POs describe what students are expected to know or be able to do by the time of graduation. After completion of the programme, the student will be able to

- acquire sound analytical and practical knowledge to formulate and solve challenging problems.
- take jobs in schools and colleges as mathematic teachers and professors, software industries, research and development organizations.
- purse higher studies in mathematical and computing sciences and to clear competitive exams like SET/ NET/ TET etc.
- learn and apply mathematics in real life situations aiming at service to the society.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

The students at the time of graduation are enabled to

- provide strong foundation and inculcate ample knowledge on topics in pure and applied mathematics, empowering the students to pursue higher degrees at reputed academic institutions.
- provide scope for interaction with international researchers and developing collaborations.
- provide knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in other scientific and engineering domains.

Master of Science (M. Sc.) Semester Scheme - CBCS
Subject: MATHEMATICS
Course Structure, Scheme of Teaching and Evaluation (2020-21 & Onwards)

	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
SEMESTER - I	**THEORY PAPERS**							
	MT1.1	Algebra	**4**	**70**	**30**	**100**	**4**	**3**
	MT1.2	Real Analysis - I	**4**	**70**	**30**	**100**	**4**	**3**
	MT1.3	Topology	**4**	**70**	**30**	**100**	**4**	**3**
	MT 1.4	Discrete Mathematics & C-Programming	**4**	**70**	**30**	**100**	**4**	**3**
	MT1.5	Ordinary Differential Equations	**4**	**70**	**30**	**100**	**4**	**3**
	PRACTICAL PAPERS							
	MP 1.6	Programming Lab-I	**4**	**40**	**10**	**50**	**2**	**3**
	MP 1.7	Programming Lab - II	**4**	**40**	**10**	**50**	**2**	**3**
	Mandatory Credits: English Language Communication Skill		**2**	**---**	**---**	**---**	**2**	**---**
SEMESTER - II	**THEORY PAPERS**							
	MT 2.1	Linear Algebra	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.2	Real Analysis - II	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.3	Complex Analysis - I	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.4	Partial Differential Equations	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.5	Numerical Methods-I	**4**	**70**	**30**	**100**	**4**	**3**
	PRACTICAL PAPERS							
	MP 2.6	Programming Lab - III	**4**	**40**	**10**	**50**	**2**	**3**
	MP 2.7	Programming Lab - IV	**4**	**40**	**10**	**50**	**2**	**3**
	Mandatory Credits: Computer Skill		**2**	**---**	**---**	**---**	**2**	**---**
SEMESTER - III	**THEORY PAPERS**							
	MT 3.1	Differential Geometry	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.2	Complex Analysis - II	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.3	Numerical Methods - II	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.4	(a) Advanced Graph Theory/ (b) Advanced Topology/ (c) Fuzzy Sets & Fuzzy Logic	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.5	(a) Fluid mechanics-I/ (b) Advanced Partial Differential Equations/ (c) Fractional Calculus	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.6	Foundations of Mathematics (Interdisciplinary-Elective paper)	**2**	**40**	**10**	**50**	**2**	**2**
	PRACTICAL PAPERS							
	MP 3.7	Programming Lab- V	**4**	**40**	**10**	**50**	**2**	**3**
SEMESTER - IV	**THEORY PAPERS**							
	MT 4.1	Measure Theory and Integration	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.2	Functional Analysis	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.3	Operations Research	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.4	(a) Riemannian Geometry/ (b) Nevanlinna Theory/ (c) Ring Theory	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.5	(a) Fluid Mechanics – II/ (b) Classical Mechanics/ (c) Mathematical Methods	**4**	**70**	**30**	**100**	**4**	**3**
	Project Work/ Report Writing							
	MT 4.6	Project	**6**	**70**	**30**	**100**	**6**	**3**
	Mandatory Credits: Personality Development		**2**	**---**	**---**	**---**	**2**	**---**
	Total Credits for the Course		**114**	**---**	**---**	**2400**	**104**	**---**

Master of Science (M. Sc.)
Subject: MATHEMATICS
Courses having focus on employability/ entrepreneurship/ skill development

Course Code	Title of the Paper	Activities with direct bearing on Employability/ Entrepreneurship/ Skill development
MT 1.1	Algebra	Employability and entrepreneurship in teaching profession
MT 1.2	Real Analysis - I	Employability and entrepreneurship in teaching profession
MT 1.3	Topology	Skill in handling issues related to machine learning
MT 1.4	Discrete Mathematics & C-Programming	Computational Skill, Employability in IT industries and statistical Departments.
MT 1.5	Ordinary Differential Equations	Problem solving skill, Employability in developing software in numerous industries, such as engineering, aviation, automotive.
MP 1.6	Programming Lab-I	Programming skill, Employability in IT industries, Entrepreneurship in Produce innovative IT solutions and services based on global needs and trends
MP 1.7	Programming Lab - II	Programming skill, Employability in IT industries, Entrepreneurship in Produce innovative IT solutions and services based on global needs and trends
MT 2.1	Linear Algebra	Employability in Pharmaceutical, Agricultural and IT industries
MT 2.2	Real Analysis - II	Employability and entrepreneurship in teaching profession
MT 2.3	Complex Analysis - I	Employability in teaching profession
MT 2.4	Partial Differential Equations	Employability in developing software in numerous industries, such as engineering, aviation, automotive, and the like, as a way to test new designs.
MT 2.5	Numerical Methods-I	Problem Solving Skill, employing numerical techniques to model and simulate to various engineering phenomena
MP 2.6	Programming Lab - III	Programming skill, Employability in IT industries, Entrepreneurship in Produce innovative IT solutions and services based on global needs and trends
MP 2.7	Programming Lab - IV	Programming skill, Employability in IT industries, Entrepreneurship in Produce innovative IT solutions and services based on global needs and trends
MT 3.1	Differential Geometry	Employability in teaching profession

MT 3.2	Complex Analysis - II	Employability in teaching profession
MT 3.3	Numerical Methods - II	Problem Solving Skill, Employability in scientific and research organizations to develop models
MT 3.4a	Advanced Graph Theory	Problem solving skill, Employability in IT industries
MT 3.4b	Advanced Topology	Acquire the skills in handling issues related to machine learning
MT 3.4c	Fuzzy Sets & Fuzzy Logic	Employability in teaching profession
MT 3.5a	Fluid mechanics-I	Employability in industries and research organizations.
MT 3.5b	Advanced Partial Differential Equations	Employability in developing software in numerous industries, such as engineering, aviation, automotive, and the like, as a way to test new designs.
MT 3.5c	Fractional Calculus	Research skill, Employability in industries and research organizations.
MT 3.6	Foundations of Mathematics (Interdisciplinary-Elective paper)	Employability in teaching profession
MP 3.7	Programming Lab- V	Programming skill, Employability in IT industries, Entrepreneurship in Produce innovative IT solutions and services based on global needs and trends
MT 4.1	Measure Theory and Integration	Employability in teaching profession
MT 4.2	Functional Analysis	Employability in teaching profession
MT 4.3	Operations Research	Computational Skill, Employability in Pharmaceutical, Agricultural, IT industries and statistical Departments.
MT 4.4a	Riemannian Geometry	Research skill, Employability in teaching profession
MT 4.4b	Nevanlinna Theory	Employability in teaching profession
MT 4.4c	Ring Theory	Employability in teaching profession
MT 4.5a	Fluid Mechanics – II	Employability in industries and research organizations.
MT 4.5b	Classical Mechanics	Research skill, Employability in industries and research organizations.
MT 4.5c	Mathematical Methods	Mathematical problem-solving skills
MT 4.6	Project	Ability to do independent investigatory work

	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
SEMESTER - I	**THEORY PAPERS**							
	MT1.1	Algebra	**4**	**70**	**30**	**100**	**4**	**3**
	MT1.2	Real Analysis - I	**4**	**70**	**30**	**100**	**4**	**3**
	MT1.3	Topology	**4**	**70**	**30**	**100**	**4**	**3**
	MT 1.4	Discrete Mathematics & C-Programming	**4**	**70**	**30**	**100**	**4**	**3**
	MT1.5	Ordinary Differential Equations	**4**	**70**	**30**	**100**	**4**	**3**
	PRACTICAL PAPERS							
	MP 1.6	Programming Lab-I	**4**	**40**	**10**	**50**	**2**	**3**
	MP 1.7	Programming Lab - II	**4**	**40**	**10**	**50**	**2**	**3**
	Mandatory Credits: English Language Communication Skill		**2**	**---**	**---**	**---**	**2**	**---**

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT1.1	**Algebra**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Students will study groups automorphism and applications.
- They will learn to verify permutation groups and fundamental theorems.
- Students will learn ring homomorphism and properties of unique factorization domain.
- Students will learn splitting fields and important theorems with properties .

Course Outcome(s):

- Upon the successful completion of the course, students will be able to
- understand Cauchy's theorem for abelian groups and its application.
- solve the Sylow's theorems and problems.
- solve problems using Gauss lemma, Eisentein criterion, polynomial ring over commutative rings.
- study the splitting fields, degree of splitting fields and normal extension.

Syllabus

UNIT-I: Groups: Lagrange's theorem, normal subgroups and quotient groups, homomorphism, isomorphism, Cauchy's theorem for abelian groups, application of Cauchy's theorem, automorphism, inner and outer automorphism.

UNIT- II: Permutation Groups: Examples, orbit, cycle, transposition, alternating groups, Cayley's Theorem, Conjugate class, class equation, Cauchy theorem for finite groups, Sylow's Theorem and Problems: solvable groups, direct products, Fundamental theorem on finite abelian groups.

UNIT- III: Rings-Homomorphism, Kernal, isomorphism, ideals and quotient rings, maximal ideal, prime ideal, principal ideal ring. Euclidean Ring: Definition and examples, greatest common divisor, prime and irreducible elements, unique factorization domain, unique factorization theorem**.** Polynomial Rings: Division Algorithm, irreducible polynomial, primitive polynomial, Gauss Lemma, Eisentein criterion, polynomial ring over commutative rings.

UNIT- IV: Extension Fields-Definition and example, algebraic extension, transitivity of algebraic extension, roots of polynomial, Remainder Theorem, Factor theorem. Splitting Fields: Degree of Splitting fields, Normal extension.

REFERENCES:

1. M. Artin :*Algebra*, Prentice hall, Upper Saddle River, New Jersey, 1991
2. K. Ciesielski,:*Set Theory for the Working Mathematician*, Cambridge University Press, Cambridge, 1997.
3. Hall and Knight: *Higher Algebra* 6th edition, Arihant Publications, India, 2016.
4. I. N. Herstein: *Topics in Algebra* 2nd edition, John Willey and Sons, New York, 1975
5. S. K. Jain, P. B. Bhattacharya and S. R. Nagpaul: *Basic Abstract Algebra*, Cambridge University Press, Cambridge, 1997.
6. S. Singh and Q. Zameeruddin: *Modern Algebra*, Vikas Publishing House, India, 1975
7. S. M. Srivatsava: *A Course on Borel Sets*, Springer- Verlag, New York, 1998.
8. U. M. Swamy, A. V. S. N. Murthy, *Algebra: Abstract and Modern 1st Edition*, Pearson Education, India, 2011.

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT1.2	**Real Analysis - I**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- To present students the elements and importance of the real analysis.
- To define and recognize the basic properties of the field of real numbers.
- To enable the students to understand differentiability of real functions and its related theorems.
- To understand and analyze the mean value theorems.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- understand the concepts of Archimedean property, perfect sets and connected sets.
- understand the concepts of convergence of sequences and series.
- test the convergence of the series.
- enumerate the limits of functions, infinite limits and limit at infinity.

Syllabus

UNIT - I: Real number System: Ordered sets, Fields, Real field, Extended real number system, Euclidean spaces. Finite, Countable and Uncountable sets, Metric spaces, Compact sets, Perfect sets, Connected sets.

UNIT - II: Numerical Sequence and Series: Convergent sequences, subsequences, Cauchy sequences, some special sequences, Series, Series of non-negative series, summation by parts, absolute convergence, addition and multiplication of series, Rearrangement.

UNIT - III: Continuity: Limits of function, Continuous function, Continuity and Compactness, Continuity and Connectedness, Discontinuity, Monotonic functions, Infinite limits and limits at infinity.

UNIT - IV: Differentiation: The derivative of real function, Mean value theorems, The continuity of derivatives, Derivatives of higher order, Taylor's theorem, Differentiation of vector valued functions.

REFERENCES:

1. W. Rudin: *Principles of Mathematical Analysis*, McGraw Hill, USA 1983.
2. H. L. Royden and P. M. Fitzpatrick: *Real Analysis*, Prentice Hall, India, 2010.
3. T. M. Apostol: *Mathematical Analysis*, Narosa Publishing House, New Delhi, India 2004.
4. S. L. Gupta & N. R. Gupta: *Principles of Real analysis*, second edition Pearson education, Delhi, India, 2003.
5. S. Goldberg: *Methods of Real Analysis*, Oxford & IBH, USA 1970.
6. W. R. Wade: *An introduction to analysis*, Second edition, Prentice Hall of India, 2000.
7. R. G. Bartle & D. R. Sherbert: *Introduction to real Analysis*, John Wiley & Sons, Inc, USA, 1982.
8. S. C. Malik and S. Arora: *Mathematical analysis*, New Age International, India, 1992.

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT1.3	**Topology**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Students will learn topological spaces.
- Students will learn continuous functions and mappings in topological spaces.
- Students will learn connectedness, compactness of topological spaces.
- Students will learn countability and separation axioms.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- know the definitions and some basics of topological spaces.
- know how to read and write proofs in topology.
- know a variety of examples and counterexamples in topology.
- distinguish Urysohn's lemma and the Tietze extension theorem.

Syllabus

Unit I: Topological Spaces: Topological Spaces, open sets, closed sets, closure, accumulation points, derived sets, interior, boundary. Bases and sub-basis, dense sets, closure operator, neighborhood system, subspaces, convergence of sequences.

Unit-II: Continuity and other Maps: Continuous maps, continuity at a point, continuous maps into R, open and closed maps, homeomorphisms, finite product spaces, projection maps.

Unit III: Connectedness and Compactness: Connected and disconnected spaces, separated sets, intermediate value theorem, components, local connectedness, path connectedness. Compactness: Cover, subcover, compactness, characterizations, invariance of compactness under maps, properties.

Unit IV: Separation Axioms: T_0, T_1, T_2, regular and T_3 spaces, normal and T_4 spaces, Urysohn's Lemma, Tietze's, Extension Theorem, completely regular and Tychonoff spaces, completely normal and T_5 spaces.

References:

1. James. Dugundji: *Topology*, 1st edition, Allyn and Bacon, Inc., 1966.
2. J. R. Munkres: *Topology- A first course*, 2nd edition, Prentice-Hall, New Jersey, 2000.
3. S. Lipschutz:*General Topology*, Schaum's series, McGraw Hill Int, New York, 1981.
4. S. Willard:*General Topology*, Elsevier Pub. Co., 1970.
5. J. V. Deshpande:*Introduction to topology*, Tata McGraw Hill Co., India, 1988.
6. G. F. Simmons:*Introduction to Topology and Modern Analysis*, McGraw Hill Book Co.,1963.
7. *J. L. Kelley: General Topology*, Graduate Texts in Mathematicsseries,Springer-Verlag, New York ,1995.
8. C. W. Baker:*Introduction to topology*, Brown (William C.) Co,U.S., 1991.

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT1.4	Discrete Mathematics & C-Programming	4	70	30	100	4	3

Course Objective(s):

- Students will learn to draw Finite Boolean lattice, Boolean expression, function and Boolean algebra to digital networks.
- Students will learn new concept of graph theory and its applications.
- Students will learn basic concepts of C-programming.
- Students will learn different type of arrays and function.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- apply the Boolean algebra to digital networks and switching circuits.
- verify different graph structures based on their characteristics and chronology.
- construct a C- Programme for various operations and write the codes efficiently.
- construct build and run more complex program and calling a function and multidimensional array.

Syllabus

UNIT -I: Lattice Theory & Boolean Algebra: Partially ordered sets, Lattice, Distributive Lattice, Complements, Demorgan's Laws. Boolean Algebra: Boolean Lattice, Finite Boolean lattice, Boolean Expression and function, Conjunctive and disjunctive normal forms, Boolean algebra to digital networks and switching circuits.

UNIT -II: Graph Theory: Basic Concepts: Different types of graphs, subgraphs, walks and connectedness. Degree sequences, directed graphs, distances and self-complementary graphs. Blocks: Cut-points, bridges and blocks, block graphs and cut-point graphs.

UNIT -III: Introduction to 'C': Development of C, Features, Constants and Variables, Data types, Operators and Expressions, Library functions. I/O Statements: Formatted and Unformatted I/O, scanf(), printf(), getchar() and putchar() functions. Control Structures: Conditional and Unconditional, If, For, While and do-while, Switch, Break and Continue, Gotostatement.

UNIT -IV: Arrays and functions: One and Multidimensional arrays, Strings and String functions, Definition and declaration of a function, Different types, calling a function, Passing parameters, Local and Global variables, Recursive functions.

REFERENCES:

1. B. Kolman, R. C. Busby and S. Ross: *Discrete Mathematical structures*, Prentice Hall of India, New Delhi, 1998.
2. K. D. Joshi: *Foundations of Discrete Mathematics*, Wiley Eastern, USA, 1989.
3. J. A. Bonday and U.S.R. Murthy: *Graph Theory with Applications*, MacMillan, London, 1977.
4. V. Krishnamurthy:*Combinatorics, Theory and Applications*, Affiliated East-West Press Pvt. Ltd., India, 2008.
5. P.B.Kottor: *Introduction to computers and C-programming*, Sapna Book House (P) Ltd, India, 2011.
6. E. Balagurusamy: Programming in ANSI-C, Tata McGraw Hill Pub. Co., India, 1992.
7. B. W. Kernighan and D. M. Ritchie: The C- Programming Language, Prentice Hall, India, 1998.
8. S. Saha and S. Mukherjee: Basic Computation and Programming with C, 1st edition, Cambridge University Press, 2017.

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT1.5	**Ordinary Differential Equations**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Recognize, classify and solve ordinary differential equations.
- Solve oscillatory and non-oscillatory differential equations.
- Solve power series solution of linear differential equations.
- Identify research problems where differential equations can be used to model the system.

Course Outcome(s):

After completing this course, the student will be able to:

- understand the concepts of existence and uniqueness of solutions.
- recognize certain basic types of first order ODEs for which exact solutions may be obtained and to apply the corresponding methods of solution.
- explore some of the basic theory of linear ODEs, gain ability to recognize certain basic types of higher-order linear ODEs for which exact solutions may be obtained, and to apply the corresponding methods of solution.
- introduced to the concept of the Frobenius method- Hermite, Laguerre, Chebyshev and Gauss Hypergeometric equations and their general solutions.

Syllabus

Unit-1: Higher Order Linear Differential Equations: Homogeneous equations and general solutions, Initial value problems, existence and uniqueness of solutions. Linear dependence and independence of solutions, solutions of non-homogeneous equations by method of variation of parameters. Non-homogeneous equations. Linear equations with variable coefficients, reduction of order of the equation.

Unit-2: Oscillations of Second Order Equations: Introduction, Oscillatory and non-Oscillatory differential equations and some theorems on it. Boundary value problems; Sturm Liouville theory; Green’s function.

Unit-3: Solution in Terms of Power Series: 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. Behavior of solution at irregular singular points and the point at infinity.

Unit-4: Successive Approximations Theory and System of First Order Equations: Introduction, solution by successive approximations, Lipschitz condition, Convergence of successive approximations, Existence and Uniqueness theorem (Picard's theorem), First order systems, Linear system of homogeneous and non-homogeneous equations (matrix method) Non-linear Equations-Autonomous Systems-Phase Plane-Critical points–stability-Liapunov direct method-Bifurcation of plane autonomous systems.

REFERENCES:

1. G.F. Simmons: *Differential Equations*, TMH Edition, New Delhi, 1974.
2. S.L. Ross: *Differential equations* (3rd edition), John Wiley & Sons, New York, 1984.
3. E.D. Rainville and P.E. Bedient: *Elementary Differential Equations*, McGraw Hill, New York, 1969.
4. E.A. Coddington and N. Levinson: *Theory of ordinary differential equations*, McGraw Hill, 1955.
5. A.C. King, J. Billingham & S.R. Otto: *Differential equations*, Cambridge University Press, 2006.
6. B. J. Gireesha, Rama S. R. Gorla, B. C. Prasannakumara, *Advanced Differential Equations*, Studerapress, New Delhi,2017.
7. E. Kreyszig, *Advanced Engineering Mathematics*, John Wieley and Sons, 2002.
8. F. Ayers, *Theory and problems of differential equations*, McGraw Hill, 1972.

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MP 1.6	**Programming Lab - I**	**4**	**40**	**10**	**50**	**2**	**3**

Course Objective(s)

- It enables the student to explore mathematical concepts and verify mathematical facts through the use of software.
- To enhances the skills in effective programming.
- To utilize the software knowledge for academic research.
- To solve problems in applied mathematics through programming

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- show proficiency in using the software C-Programming.
- understand the use of various techniques of the software for effectively doing mathematics.
- obtain necessary skills in programming.
- understand the applications of mathematics through programming.

Syllabus

Problems from MT 1.4 (Theory) may be solved with the help of C-Programming.

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MP 1.7	Programming Lab - II	4	40	10	50	2	3

Course Objective(s):

- It enables the student to explore mathematical concepts through the use of MATHEMATICA, MATLAB and *Free and Open-Source Software (FOSS) Tool*.
- To enhances the skills in effective programming in *Free and Open-Source Software (FOSS) Tool*.
- To utilize the software knowledge for academic research.
- To solve problems in applied mathematics through programming

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- effectively use the mathematical software's like Mathematica, MATLAB to solve various mathematical problems.
- understand the use of various techniques of the software's for effectively doing mathematics.
- obtain necessary skills in programming to solve ODEs.
- understand the applications of applied mathematics.

Syllabus

Problems from MT 1.5 (Theory) may be solved with the help of MATLAB, MATHEMATICA OR FOSS.

SEMESTER - II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	THEORY PAPERS							
	MT 2.1	Linear Algebra	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.2	Real Analysis - II	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.3	Complex Analysis - I	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.4	Partial Differential Equations	**4**	**70**	**30**	**100**	**4**	**3**
	MT 2.5	Numerical Methods-I	**4**	**70**	**30**	**100**	**4**	**3**
	PRACTICAL PAPERS							
	MP 2.6	Programming Lab - III	**4**	**40**	**10**	**50**	**2**	**3**
	MP 2.7	Programming Lab - IV	**4**	**40**	**10**	**50**	**2**	**3**
	Mandatory Credits: Computer Skill		**2**	**---**	**---**	**---**	**2**	**---**

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT2.1	Linear Algebra	4	70	30	100	4	3

Course Objective(s):

- Students will learn definition and examples of vector spaces, subspaces and properties.
- Students will learn linear transformations and their representation as matrices.
- Students will learn eigenvalues and eigenvectors of a linear transformation, solutions of homogeneous systems of linear equations.
- Students will learn canonical forms – similarity of linear transformations.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- verify the existence of complementary subspace of a subspace of a finite dimensional vector space.
- find out the properties of dual space, Bidual space and natural isomorphism.
- find the bilinear, quadratic and Hermitian forms and get the solutions of homogeneous systems of linear equations.
- solve Jordan blocks and Jordan forms based on ranks and signature.

Syllabus

Unit I: Definition and examples of vector spaces. Subspaces. Sum and direct sum of subspaces. Linear span. Linear dependence, independence and their basic properties. Basis. Finite dimensional vector spaces. Existence theorem for bases. Invariance of number of elements of a basis set. Dimension. Existence of complementary subspace of a subspace of a finite dimensional vector space. Dimension of sums of subspaces. Quotient space and its dimension.

Unit II: Linear transformations and their representation as matrices. The algebra of linear transformations. The rank nullity theorem. Change of basis. Dual space. Bidual space and natural isomorphism. Adjoint of a linear transformation.

Unit III: Eigenvalues and eigenvectors of a linear transformation. Diagonalization. Annihilator of a subspace. Bilinear, Quadratic and Hermitian forms. Solutions of homogeneous systems of linear equations.

Unit IV: Canonical forms – Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a linear transformation. Primary decomposition theorem. Jordan blocks and Jordan forms. Hermitian transformations, unitary and normal transformations, real quadratic forms**:** Sylvester's law of inertia, rank and signature.

References:

1. W. C. Brown: *A Second Course in Linear Algebra,* John Willey and Sons, New York, 1988.
2. W. Cheney and D. Kincaid: *Linear Algebra*, Jones and Bartlett Publishers, Canada, 2010.
3. J. Hefferon: *Linear Algebra* 3rd edition, Joshua publication, Colchester, Vermont USA, 2017.
4. I. N. Herstein: *Topics in Algebra* 2nd edition, John Willey and Sons, New York, 1975.
5. K. Hoffman and R. Kunze: *Linear Algebra* 2nd edition, Prentice Hall, India, 2001.
6. V. K. Khanna & S. K Bhamri: *A Course in Abstract Algebra*, 4th edition, Vikas Publication, India, 2013
7. J. J. Rotman, Galois Theory, 2nd edition, Universitext Springer-Verlag, New York, 1998.
8. A. R. Vashishta, J. N. Sharma, A. K. Vashishta: *Linear Algebra,* Krishna Prakashan Media, India, 2010.

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT2.2	**Real Analysis - II**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- To present students the fundamentals and significance of the real analysis.
- To recognize the existence of Riemann-Stieltjes integral, sequences and series of functions.
- To enable the students to the functions of several variables and its related theorems.
- To understand the inverse and implicit theorems and its applications.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- understand the concept of Riemann integration and differentiation.
- understand Uuniform convergence and continuity.
- apply the Stone-Weierstrass theorem.
- analyze the concept of functions of several variables.

Syllabus

Unit I: Riemann-Stieltjes integral, its existence and linearity, the integral as a limit of sum, change of variables. Mean value theorems. Functions of bounded variation. The fundamental theorem of calculus.

UNIT-2: Sequences and Series of Functions: Pointwise and uniform convergence, uniform convergence& continuity, uniform convergence & integration, uniform convergence & differentiation, equi-continuous families of functions: point wise and uniformly bounded, equi-continuous family of functions, the Stone-Weierstrass theorem.

UNIT-III: Functions of Several Variables: Linear transformations, invertible linear operators, matrix representation, differentiation, partial derivatives, gradients, directional derivative, continuously differentiable functions, the contraction principle.

UNIT-IV: The Inverse and Implicit Function Theorem: The inverse function theorem, implicit function theorem with examples, Jacobians, derivatives of higher order and differentiation of integrals.

REFERENCES:

1. W. Rudin :*Principles of Mathematical Analysis*, McGraw Hill, USA 1983.
2. H. L. Royden and P. M. Fitzpatrick: *Real Analysis*, Prentice Hall, India, 2010.
3. T. M. Apostol: *Mathematical Analysis*, Narosa Publishing House, New Delhi, India 2004.
4. S. L. Gupta & N. R. Gupta: *Principles of Real analysis*, second edition Pearson education, Delhi, India, 2003.
5. S. Goldberg: *Methods of Real Analysis*, Oxford & IBH, USA 1970.
6. R. G. Bartle & D. R. Sherbert: *Introduction to real Analysis*, John Wiley & Sons, Inc, USA, 1982.
7. S. Lang: *Real and Functional Analysis*, Springer-Verlag, 1993.
8. S. C. Malik and S. Arora: *Mathematical analysis*, New Age International, India, 1992.

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT2.3	**Complex Analysis - I**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Students will learn complex plane and its algebra.
- Students will learn power series and radius of convergence.
- Students will learn complex integration.
- Students will learn series expansions (Taylor's and Laurent's series).

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- know the definitions and some basics of Complex plane.
- do basic operations on complex numbers.
- find out radius of convergence.
- know how to read and write proofs in complex integration.

Syllabus

Unit - I: Complex plane its algebra and topology. Holomorphic maps. Analytic functions. Harmonic functions. Hormonic conjugate function; their relation to analytic functions.

Unit - II: Power series. Radius of convergence. Integration and differentiation of power series. Uniqueness of series representation. Relation between power series and analytic functions: trigonometric, exponential and logarithmic functions.

Unit - III: Review of complex integration. Basic properties of complex integration. winding number. Cauchy-Goursat theorem. Cauchy theorem for a disc, triangle and rectangle. Liouville theorem. Fundamental theorem of algebra. Morera's theorem.

Unit - IV: Taylor and Laurent's expansion. Singularities. Poles. Removable and Isolated singularities. Classification of singularities using Laurent's expansion. Behaviour of analytic function in the neighborhood of singularities. Principle of analytic continuation, Residue theorem and contour integrals. Argument principle, Rouche's theorem its applications.

References:

1. J. B. Conway: *Functions of One Complex Variable*, 2nd edition, Graduate Texts in Mathematics, Springer-Verlag, New York–Berlin, 1978; first edition, 1973.
2. Ahlfors, L. V.: *Complex Analysis*, 3rd edition, New York, McGraw-Hill, 1979.
3. S. Ponnusamy: *Foundations of Complex Analysis*, 2nd Edition, Narosa Publishing House, India, 2005.
4. R. V. Churchil and J. W. Brown: *Complex Variables and Applications*, 4th Edition, McGraw Hill Book Company, New York, 1984.
5. Rudin, W.: *Real and Complex Analysis*, New York, McGraw-Hill, 1966.
6. S. L. Segal: *Nine Introductions in Complex Analysis*, revised edition, North-Holland Mathematics Studies, Elsevier, Amsterdam, 2008; first edition, 1981.
7. I. Stewart and D. Tall: *Complex Analysis*, Cambridge University Press, 1983.
8. H. S. Kasana: *Complex Variables- Theory and Applications*, 2nd edition, PHI Learning Pvt. Ltd., India, 2005.

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT2.4	**Partial Differential Equations**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- To learn theory of partial differential equations and solution methods.
- Provide advanced knowledge and good understanding of nature of PDEs like parabolic, elliptic, hyperbolic.
- Learn to solve systems of linear and non-linear equations.
- Solve wave, Laplace and heat equations in cylindrical and spherical polar coordinates.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- classify PDEs, apply analytical methods, and physically interpret the solutions.
- understand basic properties of standard PDEs.
- Demonstrate accurate and efficient use of Duhamel's Principle techniques and their applications in the theory of PDE.
- Demonstrate capacity to model physical phenomena using PDEs.

Syllabus

UNIT-I: First Order Partial Differential Equations: First order partial differential equations: Basic definitions, Origin of PDEs, classification. The Cauchy problem, the method of characteristics for semi linear, quasi linear and non-linear equations, complete integrals,

UNIT-II: Second Order Partial Differential Equations: 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.

UNIT-III: Wave equation: Solutions by Separation of variables and integral transforms. The Cauchy problem. Solution of wave equation in cylindrical and spherical polar coordinates

Laplace equation: Solutions by Separation of Variables and integral transforms. Dirichlet's and Neumann's problems, Dirichlet's problem for a rectangle, half plane and circle. Solution of Laplace equation in cylindrical and spherical polar coordinates

UNIT-IV: Diffusion equation: Solutions by separation of variables and integral transforms. Duhamel's Principle. Solution of diffusion equation in cylindrical and spherical polar coordinates. Solution of nonlinear PDE`s: similarity solutions.

REFERENCES:

1. N. Sneddon: *Elements of PDE's*, McGraw Hill Book company Inc., 2006.
2. L Debnath: *Nonlinear PDE's for Scientists and Engineers*, Birkhauser, Boston, 2007.
3. F. John: *Partial differential equations*, Springer, 1971.
4. F. Treves: *Basic linear partial differential equations*, Academic Press, 1975.
5. M.G. Smith*: Introduction to the theory of partial differential equations*, Van Nostrand, 1967.
6. Shankar Rao: *Partial Differential Equations*, PHI,Newdelhi, 2006.
7. P. Prasad and R. Ravindran: *Partial Differential Equations*, Wiley Eastern (1998)
8. S. J. Farlow: *P. D. E. for Scientists and Engineers*, John Wiley (1998).

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT2.5	Numerical Methods-I	4	70	30	100	4	3

Course Objective(s):

- This introductory course presents students some classical and commonly used numerical methods in various disciplines involving computing and numerical approximation and solution of equations.
- The course teaches students how to choose an appropriate numerical method for a particular problem and to understand the advantages and limitations of the chosen numerical scheme for a given mathematical problem so that results from the computation can be properly interpreted.
- The course also highlights important theoretical considerations on Interpolation and approximation.
- To develop the mathematical skills of the students in the areas of numerical methods.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- Apply numerical methods to find our solution of algebraic equations using different methods under different conditions, and numerical solution of system of algebraic equations.
- Apply various interpolation methods and finite difference concepts.
- Work out Gauss Elimination method, Gauss-Jordan method, LU factorization, triangularization method, iteration methods: Gauss Jordan methods, Gauss-Seidel method, successive over relaxation method, convergence criteria.
- Work on the eigenvalues and eigenvectors of matrix by Jocobi's method, given's method, house holder's method, power method, inverse power method.

Syllabus

UNIT-1: Solutions of Linear System of Equations: Introduction to Direct Methods via., Gauss Elimination method, Gauss-Jordan method, LU factorization, Triangularization method, Iteration Methods: Gauss Jordan methods, Gauss-Seidel method, successive over relaxation method, convergence criteria, and problems on each method.

UNIT-2: Solutions of Nonlinear/Transcendental Equations: Fixed point iteration, method of Falsi position, Newton Raphson method, secant method, Regula-Falsi method, Muller's method, Aitkin's δ^2 method, orders of convergence of each method. problems on each method. Sturm sequence for identifying the number of real roots of the polynomial functions. Extraction of quadratic polynomial by Bairstow's method.

UNIT-3: Eigenvalues and Eigenvectors of a Matrix: The characteristics of a polynomial, The eigenvalues and eigenvectors of matrix by Jocobi's method, given's method, house holder's method, power method, inverse power method, QR Algorithm.

UNIT-4: Interpolation and Approximation Theory: Polynomial interpolation theory, Gregory Newtons forward, back ward and central difference interpolation polynomial. Lagranges interpolation polynomial, truncation error. Hermite interpolation polynomial, inverse interpolation, piece wise polynomial interpolation, trigonometric interpolation, convergence analysis, Spline approximation, cubic splines, best approximation property, least square approximation for both discrete data and for continuous functions.

REFERENCES:

1. R. K. Jain, S. R. K. Iyengar and M. K. Jain: *Numerical methods for scientific and Engineering computation*, Wiley Eastern, 2001.
2. S. D. Conte and Carl De Boor: *Elementary Numerical Analysis*, McGraw Hill, 2000.
3. C. E. Froberg: *Introduction to Numerical Analysis*, Addison Wesley, 1995.
4. M. K. Jain: Numerical Solution of Differential Equations, Wiley Eastern, 1990.
5. G. D. Smith:*Numerical Solution of PDE*. Oxford University Press, 1998.
6. A Iserles: *A first course in the numerical analysis of differential equations*,2nd edition, Cambridge texts inapplied mathematics, 2008.
7. D. Kincade and W Cheney: *Numerical analysis*,3rd edition American Mathematical Society, 2002.
8. R.L. Burden and J.D. Faires: *Numerical Analysis*,7th edition Thomson-Brooks/Cole, 1989.

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MP 2.6	Programming Lab - III	4	40	10	50	2	3

Course Objective(s):

- Students will learn to write the code for verifying vector spaces, subspaces and properties using MATLAB.
- Students will learn to write the code for linear transformations and their representation as matrices.
- Students will learn to write the code for first order partial differential equations and second order partial differential equations.
- Students will learn to write the code for wave equation Laplace equation and diffusion equation.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- build a MATLAB program for verifying vector spaces, subspaces and properties.
- build a MATLAB program for represent the set of given linear vectors into matrix forms.
- build a MATLAB program for finding different solutions of first order partial differential equations and second order partial differential equations.
- build a MATLAB program for finding solutions by separation of variables and integral transforms for wave equation Laplace equation and diffusion equation.

Syllabus

Problems from MT 2.1 &MT 2.4 (Theory) may be solved with the help of MATLAB, MATHEMATICA OR FOSS.

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MP 2.7	Programming Lab - IV	4	40	10	50	2	3

Course Objective(s):

- It enables the student to explore mathematical concepts and verify mathematical facts through the use of software and also enhances the skills in programming.
- Show proficiency in using the software C-Programming.
- Students will learn to write the code for verifying vector spaces, subspaces and properties using FOSS.
- Students will learn to write the code for linear transformations and their representation as matrices.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- understand the use of various techniques of the software for effectively doing mathematics.
- obtain necessary skills in programming.
- understand the applications of mathematics.
- utilize the software knowledge for academic research.

Syllabus

Problems from MT 2.5 (Theory) may be solved with the help of C-Programming.

	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
SEMESTER - III		**THEORY PAPERS**						
	MT 3.1	Differential Geometry	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.2	Complex Analysis - II	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.3	Numerical Methods - II	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.4	(a) Advanced Graph Theory/ (b) Advanced Topology/ (c) Fuzzy Sets & Fuzzy Logic	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.5	(a) Fluid mechanics-I/ (b) Advanced Partial Differential Equations/ (c) Fractional Calculus	**4**	**70**	**30**	**100**	**4**	**3**
	MT 3.6	Foundations of Mathematics (Interdisciplinary-Elective paper)	**2**	**40**	**10**	**50**	**2**	**2**
		PRACTICAL PAPERS						
	MP 3.7	Programming Lab- V	**4**	**40**	**10**	**50**	**2**	**3**

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.1	Differential Geometry	4	70	30	100	4	3

Course Objective(s):

- The course introduces the fundamentals of differential geometry primarily by focusing on the theory of curves and surfaces in three space.
- To familiarize the students with basic concepts of differential geometry as the subject has got application in general theory of relativity, cosmology and other related disciplines.
- To develop the problem-solving skills arising in geometry by using the techniques of differential calculus and integral calculus.
- To solve real life problems by thinking logically about curves and surfaces.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- to give the basic knowledge of classical differential geometry of curves and surfaces in.
- to develop arguments in the geometric description of curves and surfaces in.
- get introduced to the notion of Serret-Frenet frame for space curves and the involutes and evaluates of space curves with the help of examples.
- get knowledge towards the notion of Frenet-Serret Formulae (i.e., compute the curvature and torsion of space curves) with the help of examples.

Syllabus

Unit I: Introduction, Euclidean space, Tangent vectors, Vector fields, Directional derivatives, curves in E^3, 1 – Forms, differential forms, Mappings on Euclidean spaces, derivative map, dot product in E^3, dot product of tangent vectors, Frame at a point.

Unit II: Cross product of tangent vectors, curves in E^3, arc length, reparameterization, The Frenet formulas, Frenet frame field, curvature and torsion of a unit speed curve. Arbitrary speed curves, Frenet formulas for arbitrary speed curve, Covariant derivatives, Frame field on E^3, connection forms of a frame field, Cartan's structural equations.

Unit III: Isometry in E^3, Derivative map of isometry in E^3, Calculus on a surface, co-ordinate patch, proper patch, surface in E^3, Monge patch, Patch computations, parametrization of a cylinder, Differentiable functions and tangent vectors, tangent to a surface, tangent plane, Vector-field, tangent and normal vector-fields on a surface.

Unit-IV: Mapping of surfaces, topological properties of surfaces, manifolds. Shape operators, normal curvature, Gaussian curvature, computational techniques, special curves in surfaces.

REFERENCES:

1. Barrett. O. Neill, *Elementary Differential Geometry,* Academic Press, New York (1998)
2. T.J.Willmore, *An introduction to Differential Geometry*, Oxford University Press (1999)
3. N.J.Hicks, *Notes on Differential Geometry*, Van Nostrand, Princeton (2000)
4. Nirmala Prakash, *Differential Geometry - An integrated approach*, Tata McGraw Hill Pub. Co. New Delhi (2001).
5. M. P. Do Carmo, *Differential Geometry of Curves and Surfaces*, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976.
6. J. A. Thorpe, *Elementary Topics in Differential Geometry*, Springer (Undergraduate Texts in Mathematics), 1979.
7. L. P. Eisenhart, *A Treatise on the Differential Geometry of Curves and Surfaces*, Ginn and Company, Boston, 1909.
8. A. Gray, *Differential Geometry of Curves and Surfaces*, CRC Press, 1998.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.2	**Complex Analysis - II**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Students will learn Maximum and minimum modulus principle.
- Students will learn Open mapping theorem and some related theorems.
- Students will learn Conformal mapping.
- Students will learn Analytic continuation.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- write proofs of maximum and minimum modulus principle.
- distinguish and utility of open mapping theorem.
- know a conformal mapping and cross ratios.
- apply Riemann mapping theorem.

Syllabus

Unit I: Maximum Modulus Principle. Minimum Modulus Principle. Schwarz's Lemma. Some applications of Schwarz's Lemma. Basic properties of univalent functions.

Unit II: Open Mapping Theorem. Deduction of Maximum Modulus Principle using Open Mapping theorem. Hadamard's Three Circle theorem.

Unit III: Conformal Mapping. Linear transformations. Unit disc transformations. Sequences and series of functions. Normal families.

Unit IV: Weierstrasstheorem, Hurwitz's theorem. Montel's theorem. Riemann mapping theorem. Analytic continuation of functions with natural boundaries. Schwarz's reflection principle.

REFERENCES

1. L. V. Ahlfors: *Complex Analysis*, 3rd ed. New York, McGraw-Hill, 1979.
2. J. B. Conway: *Functions of One Complex Variable*, 2nd edition, Graduate Texts in Mathematics, Springer-Verlag, New York–Berlin, 1978; first edition, 1973.

3. S. Ponnusamy: *Foundations of Complex Analysis*, 2nd Edition, Narosa Publishing House, India, 2005.
4. R. V. Churchil and J. W. Brown: *Complex Variables and Applications*, 4th Edition, McGraw Hill Book Company, New York, 1984.
5. H. S. Kasana: *Complex Variables- Theory and Applications*, 2nd edition, PHI Learning Pvt. Ltd., India, 2005.
6. H. A. Priestley: *Introduction to Complex Analysis*, 2nd Edition, Oxford University Press, Indian Edition, 2003.
7. S. L. Segal: *Nine Introductions in Complex Analysis*, revised edition, North-Holland Mathematics Studies, Elsevier, Amsterdam, 2008; first edition, 1981.
8. I. Stewart and D. Tall: *Complex Analysis*, Cambridge University Press, 1983.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.3	Numerical Methods - II	4	70	30	100	4	3

Course Objective(s):

- This introductory course presents students some classical and commonly used numerical methods in various disciplines involving computing and numerical approximation and solution of equations.
- To teach theory and applications of numerical methods in linear systems, finding eigenvalues, eigenvectors, interpolation and applications, solving ODEs, PDEs and dealing with statistical problems like testing of hypotheses.
- To lay foundation of computational mathematics for specialized studies and research
- To develop the mathematical skills of the students in the areas of numerical methods.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- Solve boundary value problems method of undetermined coefficients, finite difference methods, shooting method, and midpoint method.
- Work out numerical differentiation and integration whenever and wherever routine methods are not applicable.
- Work out on boundary value problems method of undetermined coefficients, finite difference methods, shooting method, and midpoint method.
- Work numerically on the partial differential equations using different methods through the theory of finite differences.

Syllabus

UNIT-I: Numerical Differentiation and Integration: Introduction, errors in numerical differentiation, extrapolation methods, cubic spline method, differentiation formulae with function values, maximum and minimum values of a tabulated function, partial differentiation. Numerical Integration, Newton-Cotes integration methods; Trapezoidal rule, Simpson's 1\3rd rule, Simpson's 3\8th rule and Weddle's rule. Gaussian integration methods and their error analysis. Gauss-Legendre, Gauss-Hermite, Gauss-Laguerre and Gauss-Chebyshev integration methods and their error analysis. Romberg integration, Double integration.

UNIT-II: Numerical Solutions of Initial Value Problems (Ordinary Differential Equations): Introduction**,** Derivation of Taylor's series method**,** Euler's method, Modified Euler Method, Runge-Kutta Second, Third and Forth order methods, Runge-Kutta-Gill method, Predictor-Corrector methods; Milne's method, Adam's Bashforth Moulton method.

UNIT-III: Solutions of Boundary Value Problems (Ordinary Differential Equations): Introduction, solution of boundary value problems method of undetermined coefficients, finite difference methods, shooting method, and midpoint method.

UNIT - IV: Numerical Solutions of Partial Differential Equations: Introduction, derivation of finite difference approximations to the derivatives, solution of Laplace equation by Jacobi, Gauss Seidel and SOR methods, ADI method, Parabolic, solution of heat equation by Schmidt and Crank-Nicolson methods, solution of wave equation using finite difference method.

REFERENCES:

1. S. Larsson and V. Thomee: *Partial differential equations with numerical methods*, Springer, 2008.
2. J. W. Thoma: *Numerical partial differential equations: finite difference methods*, 2^{nd} edition, pringer, 1998.
3. R. K. Jain, S. R. K. Iyengar and M. K. Jain: *Numerical methods for scientific and Engineering computation*, Wiley Eastern, 2001.
4. S. D. Conte and Carl De Boor: *Elementary Numerical Analysis*, McGraw Hill, 2000.
5. M. K. Jain: *Numerical Solution of Differential Equations*, Wiley Eastern, 1990.
6. G. D. Smith: *Numerical Solution of PDE*, Oxford University Press, 1998.
7. A. Iserles: *A first course in the numerical analysis of differential equations*, 2^{nd} edition, Cambridge texts in applied mathematics, 2008.
8. R.L. Burden and J.D. Faires: *Numerical Analysis*, 7^{th} edition, Thomson-Brooks/Cole, 1989.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.4	(a) Advanced Graph Theory	4	70	30	100	4	3

Course Objective(s):

- Students will learn Graph Isomorphism and Connectivity using Factorization, Covering matching.
- Students will study different Graph valued functions like Line graphs, subdivision graph and total graphs along with properties.
- Students will learn the concept of Graph Coloring, proper coloring, properties, Chromatic numbers and chromatic polynomials and domination of graphs.
- Students will learn the algebraic application of graph theory in the form of Spectra.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- factorize the given graphs and verify their connectivity index.
- draw different Graph Invariants using properties of edges and vertices.
- study the Graphs based on their proper coloring and properties when sorted into chromatic polynomials.
- algebraically construct the graphs with the given Adjacency incidence matrices, find their eigenvalue spectra further studying group of graphs and automorphism properties.

Syllabus

UNIT - I: Graph Isomorphism and Connectivity: Factorization, 1- factorization, 2 factorizations, decomposition and labeling of graphs.Covering: covering. edge covering, independence number, matching and matching polynomial.

UNIT - II: Graph valued functions: Line graphs, subdivision graph and total graphs along with properties. Graph homomorphism, isomorphism. Planarity: Planar graphs, outerplanar graphs. Kuratowaski criterion planarity and Euler polyhedron formula.

UNIT - III: Coloring: Graph Coloring, proper coloring, properties, Chromatic numbers and chromatic polynomials. Domination: Dominating sets, domination number, domatic number and its bounds, independent domination number of a graph. Theory of External graphs and Ramsey Theory.

UNIT - IV: Spectra of Graphs: Adjacency matrix, incidence matrix. characteristic polynomials, eigenvalues, graph parameters, strongly regular graphs and Friendship Theorem. Groups and Graphs: Automorphism in group of a graph, operation on permutation graphs and composition of graphs.

REFERENCES:

1. M. Behzad, G. Chartrandand L. Lesniak: *Graphsand Diagraphs*, Cambridge University Press.1981.
2. J. A. Bondy and V. S. R. Murthy: *Graph theory with Applications*, MacMillan Press, London, 1976.
3. F. Buckley and F. Harary: *Distance in Graphs*, Addison-Wesley Publication, Redwood city,CA, 1990.
4. D. Cvetkovic, M. Dooband H. Sachs: *Spectrain Graphs*, Academic Press, New York, 1980.
5. N. Deo: *Graph Theory with Applications to Engineering and Computer Science*, Prentice hall press, India, 1995.
6. F. Harary: *Graph Theory*, Addison Wesley, Readingmass, l969.
7. D. B. West: *Introduction to Graph Theory*, Prentice hall, India, 2001.
8. K. Ulrich and K .Kolja: *Algebraic Graph Theory*, De Gruyter, Berlin, Germany, 2011.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.4	(b) Advanced Topology	4	70	30	100	4	3

Course Objective(s):

- Students will learn Countability axioms in topological spaces.
- Students will learn Metric spaces and metrizability of topological spaces.
- Students will learn Product spaces in topological spaces.
- Students will learn Algebraic topology.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- know the definitions and some basics of Countability of topological spaces.
- know how to read and write proofs in metric spaces and metrizability.
- distinguish Urysohn's lemma and the Tietze extension theorem.
- know a variety of examples and counterexamples in topology.

Syllabus

Unit-I: Countability Axioms: First and Second Axioms of countability. Lindelof spaces, separable spaces, countably compact spaces, Limit point compact spaces.

Unit-II: Metric Spaces and Metrizabilty: Separation and countability axioms in metric spaces, convergence in metric spaces, complete metric spaces, Urysohn's Metrisation theorem, Bing's Metrisation theorem, Nagata-Smirnov Metrisation theorem.

Unit-III: Product Spaces: Arbitrary product spaces, product invariance of separation and countability axioms. Tychonoff's theorem, product invariance of connectedness.

Unit-IV: Algebraic Topology: Homotopy of paths, covering spaces, fundamental group of circles, retractions and fixed points, fundamental theorem of algebra.

REFERENCES

1. James. Dugundji, Topology Allyn and Bacon (Reprinted by PHI and UBS)
2. J. R. Munkres, Topology – A first course PHI (2000)
3. S. Lipschutz, General Topology, Schaum's series, McGraw Hill Int (1981)
4. W. J. Pervin, Foundations of general topology, Academic Press (1964)
5. S. Willard, General Topology, Elsevier Pub. Co. (1970)
6. J. V. Deshpande, Introduction to topology, Tata McGraw Hill Co. (1988)
7. S. Nanda and S. Nanda, General Topology, MacMillan India (1990)
8. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Co. (1963)
9. J. L. Kelley, General Topology, Van Nostrand Reinhold Co. (1995).
10. C. W. Baker, Introduction to topology, W. C. Brown Publisher (1991).

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.4	**(c) Fuzzy Sets &Fuzzy Logic**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Students will learn fundamental concepts of Fuzzy sets.
- Students will learn operations on Fuzzy sets.
- Students will learn Fuzzy relations and its arithmetic.
- Students will learn Fuzzy topological spaces and its applications.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- know the definitions and some basics of fuzzy sets.
- do operations on fuzzy sets.
- know fuzzy relations and its operations.
- know a variety of examples and counter examples of fuzzy topology.

Syllabus

Unit I: Introduction: From classical Sets (crisp sets) to fuzzy sets, Basic definitions, basic operations on fuzzy sets, fuzzy sets induced by mappings, Types of fuzzy sets. **Fuzzy Sets Versus Crisp Sets:** The α - cuts, strong α - cuts, properties of cuts, representation of fuzzy sets, decomposition theorems, Zadeh's extension principle.

Unit II: Operations on Fuzzy Sets: Types of operations, fuzzy complements, fuzzy intersections, t – norms, fuzzy unions, t – conforms, combinations of operations, aggregation operations. **Fuzzy Arithmetic:** Fuzzy numbers, Linguistic variables, arithmetic operations on intervals and fuzzy numbers, fuzzy equations.

Unit III: Fuzzy Relations: Crisp and fuzzy relations, Projections and cylindric extensions, binary fuzzy relations, membership matrices and sagittal diagram, inverse and composition of fuzzy relations, binary fuzzy relation on a single set, fuzzy equivalence relation, fuzzy ordering relation, fuzzy morphisms, sup and inf compositions. **Fuzzy Logic:** An overview of classical logic. Multivalued logics, fuzzy propositions, fuzzy quantifiers, Linguistic hedges, inferences from conditional fuzzy propositions, qualified fuzzy propositions and quantified fuzzy propositions.

Unit IV: Fuzzy Topology: Change's and Lowen's definition of fuzzy topology. Continuity, open and closed maps. α - shading families, α - connectedness and α - compactness. **Applications:** Applications of fuzzy sets and fuzzy logic to various disciplines including Computer Science.

REFERENCES

1. G. J. Klir and B. Yuan: Fuzzy Sets and Fuzzy Logic; Theory and Applications, PHI (1997)
2. A. Kaufmann: Introduction to the theory of Fuzzy Subsets, Vol. – I, Academic Press (1975)
3. L. Y. Ming & L. M. Kung: Fuzzy Topology, World Scientific Pub. Co. (1997)
4. T. J. Ross: Fuzzy Logic with Engineering Applications, Tata McGraw Hill (1997)
5. S. V. Kartalopoulos: Understanding Neural Networks and Fuzzy Logic, PHI (2000)
6. H. J. Zimmermann: Fuzzy Set Theory and its Applications, Allied Pub. (1991)
7. N. Palaniappan: Fuzzy Topology, Narosa (2002)

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.5	(a) Fluid mechanics-I	4	70	30	100	4	3

Course Objective(s):

➢ To familiarize the students with basic concepts of fluid dynamics.

➢ To understand the applications in medical, astrophysical, geophysical, agricultural, aero dynamical and other related disciplines.

➢ To develop the problem-solving skills essential to fluid dynamics in practical applications.

➢ **To** understand the fundamental knowledge of fluids and its properties.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- describe the concepts and equations of fluid dynamics.
- apply thermodynamic control volume concepts in fluid dynamics for applications that include momentum, mass and energy balances.
- analyze the approximate solutions of the Navier-Stokes equation.
- appreciate the role of fluid dynamics in day-to-day life.

Syllabus

Unit - I: Introduction and Preliminaries : Definitions of fluid dynamics and fluid statics, Properties of Fluids , classification of fluids, viscosity, kinematic viscosity, Newton law of viscosity, Newtonian fluid and non-Newtonian fluid, rotational and irrotational flows, Motion of Inviscid Fluids: Pressure at a point in a fluid at rest and that in motion, Euler’s equation on motion, Barotropic flows, Bernoulli’s equations in standard forms, illustrative examples thereon.

Unit - II: Two Dimensional Flows of Inviscid Fluids: Meaning of two- dimensional flows and examples, Stream function, Complex potential, Line Sources and Line Sinks, Line Doublets and Line Vortices, Milne Thomson circle theorem and Applications, Blasius theorem.

Unit -III: Navier-Stoke’sequation: Stoke’s law, conservation of mass, derivation of Navier-Stoke’s equations of motion of a viscous fluid (i) Cartesian coordinates and (ii) vector form. energy equation, conservation of energy, diffusion of vorticity, energy dissipation due to viscosity, vortex motion, circulation, Kelvin’s circulation theorem, Helmhotz vorticity equation, performance in vorticity and circulation, Kelvin’s minimum energy theorem.

Unit - IV: Exact solutions of the Navier-Stoke'sequation: Standard applications, i) plane Poiseuille and Hagen Poiseuille flows ii) Couette flow iii) Steady flow between concentric cylinders iv) Beltrami flows (iv) Slow and steady flow past a rigid sphere and cylinder. Standard applications, Stoke's first problem and second problem.

References:

1. G. K. Bachelor: An Introduction to Fluid Mechanics, Foundation Books, New Delhi, (1994).
2. R. K. Rathy: An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, (1976)
3. D. J. Tritton, Physical fluid dynamics, Oxford Science publication, second edition, 1987.
4. S.W. Yuan, foundations of fluid mechanics, Third edition, Prentice – Hall International Inc. London.
5. Schlichting H., Boundary layer theory, McGraw-Hill, 1979.
6. Nield D. A. and Bejan A., Convection in porous media, Springer, 2006.
7. F. Chorlton: Text Book of Fluid Dynamics, CBS Publishers, New Delhi, (1985).
8. L. D. Landav and E. M. Lipschil: Fluid Mechanics, Pragamon Press, London, (1985)

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.5	**(b) Advanced Partial Differential Equations**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Investigating solution of boundary values problems for PDEs.
- Explore the possibility of finding approximate solutions using numerical methods in the absence of analytical solutions of various PDEs.
- Find the solutions of PDEs using Fourier transform and Laplace transform.
- Solving nonlinear PDEs through various methods such as similarity method, homotopy and continuation method etc

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- investigate boundary values problems and point out its significance.
- use knowledge of numerical methods to find approximate solutions of various PDEs.
- transform PDEs into integral forms through Fourier transform and Laplace transforms.
- analyze the solutions of nonlinear PDEs.

Syllabus

UNIT- I: Solution of boundary value problems: Green's function method for Hyperbolic, Parabolic and Elliptic equations.

UNIT – II: 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. Explicit finite difference schemes for hyperbolic equations, wave equation in one dimension.

UNIT – III: Fourier transform, Laplace transform: Solution of partial differential equation by Laplace and Fourier transform methods.

UNIT – IV: Solution to nonlinear partial differential equations. Similarity methods, Self-similar solution and the method of Lie-group invariance, Homotopy and continuation methods.

REFERENCES:

1. W. Ames, Numerical Method for Partial Differential Equation, Academic Press, 2008.
2. Phoolan Prasad and Renuka Ravindran, Partial Differential Equations, New Age International, 1985.
3. Shankar Rao: Partial Differential Equations, PHI, 2006
4. Lokenath Debnath, Nonlinear Partial Differential Equations for Scientists and Engineers, Birkhauser, Boston, 2007.
5. 5. N. Sneddon, Elements of PDE's, McGraw Hill Book company Inc., 2006.
6. J. N. Sharma, K. Singh, Partial Differential Equations for Engineers and Scienists, Narosa, 2nd Edition.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.5	(c) Fractional Calculus	4	70	30	100	4	3

Course Objective(s):

- The course introduces the basics of the fractional calculus, or more aptly called the calculus of derivatives and integrals to an arbitrary order.
- To familiarize the students with basic concepts of special functions (Gamma functions, Mittag-Leffler function and Wright function) and their properties.
- To Analyze and to develop the problem-solving skills for fractional differential equations by various methods.
- To apply the concept of fractional calculus to analyze and understand the real world problems

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- get introduced to the notion of Riemann Liouville and Caputo fractional derivatives.
- get knowledge towards the properties of fractional derivatives including linearity, Liebniz rule and composite functions.
- understand the various methods for the solutions to differential equations of fractional order.
- understand the Existence, uniqueness and stability of solutions of fractional differential equations.

Syllabus

Unit-I: Special Functions of the Fractional Calculus: Gamma function, Mittag-Leffler function, wright function and their properties.

Unit-II: Fractional Calculus: Introduction and history of the fractional calculus. Differential and integral operators with respect to Grunwald-Letnikov, Reimann-Liouville, Caputo and others. Properties of fractional derivatives including linearity. Leibniz rule and composite function of a fractional derivative.

Unit – III: Various methods for the solutions to fractional differential equations:

Unit IV: Analysis of fractional differential equations, existence uniqueness and stability of solutions of fractional differential equations. The Laplace transform method, Mellin transform method, Power series method and other numerical methods to solve linear and nonlinear fractional differential equations. Applications of fractional differential equations to solve and analyze various problems.

REFERENCES:

1. I. Podlubny, Fractional differential equations, Academic Press, (1998).
2. K.S. Miller, B. Ross, An Introduction to the fractional calculus, John Wiley, New York, (1993).
3. K.B. Oldham, J. Spanier, The fractional calculus; Theory and applications of differentiation and integration to arbitrary order, Academic Press, New York and London, (1974).
4. A. Kilbas, H. M. Srivastava and J.J. Trujillo, Theory and applications of fractional differential equations, Elsevier, Amsterdam, (2006).

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT3.6	**Foundations of Mathematics (Interdisciplinary-Elective paper)**	**2**	**40**	**10**	**50**	**2**	**2**

Course Objective(s):

- To enable students to understand fundamentals of set theory.
- Students will learn mathematical logic and principle of mathematical induction.
- To enable students to learn quantitative aptitude.
- Students will learn interpret data.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- identify relations and functions.
- solve permutation and combination problems.
- find GCD, LCM of numbers, simple interest and compound interest.
- plot bar graph, pie-graph and line graph.

Syllabus

Unit I: Set Theory: Union, intersection, Complementation, cross product of sets, relations, functions, properties functions, Equivalence relation,

Unit-II: Mathematical Logic, Logical connectives, two valued & three valued logics, Applications. Mathematical Induction, Permutations and Combinations, Binomial Theorem.

Unit-III: Quantitative Aptitude: Arithmetic ability, Percentage, Profit and Loss, Ratio and Proportion, Partnership, Numbers GCD & LCM, Time and Work, Simple and Compound Interest, Volume surface and area,

Unit-IV: Mental / logic ability and data interpretation –Races & Games of skills, Stocks and Shares, Bankers Discount, Heights and distance, odd man out series, Tabulation, Bar graph, Pie graph, Line graphs.

REFERENCES:

1. R. S. Agarawal, *Quantitative Aptitude*, S. Chand & Co.
2. N. D. Vohra, *Quantitative Techniques in Management*, Tata McGraw Hill.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MP 3.7	Programming Lab - V	4	40	10	50	2	3

Course Objective(s):

- It enables the student to explore mathematical concepts through the use of MATHEMATICA, MATLAB and *Free and Open-Source Software (FOSS) Tool*.
- To enhances the skills in effective programming in *Free and Open-Source Software (FOSS) Tool*.
- To utilize the software knowledge for academic research.
- To solve problems in applied mathematics through programming

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- obtain necessary skills in programming.
- understand the use of various techniques of the software's for effectively doing mathematics.
- utilize the software knowledge for academic research.
- understand the applications of applied mathematics.

Syllabus

Problems from MT 3.3 (Theory) may be solved with the help of C-Programming.

	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
SEMESTER - IV	THEORY PAPERS							
	MT 4.1	Measure Theory and Integration	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.2	Functional Analysis	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.3	Operations Research	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.4	(d) Riemannian Geometry/ (e) Nevanlinna Theory/ (f) Ring Theory	**4**	**70**	**30**	**100**	**4**	**3**
	MT 4.5	(d) Fluid Mechanics – II/ (e) Classical Mechanics/ (f) Mathematical Methods	**4**	**70**	**30**	**100**	**4**	**3**
	Project Work/ Report Writing							
	MT 4.6	Project	**6**	**70**	**30**	**100**	**6**	**3**
	Mandatory Credits: Personality Development		**2**	**---**	**---**	**---**	**2**	**---**
	Total Credits for the Course		**114**	**---**	**---**	**2400**	**104**	**---**

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.1	**Measure Theory and Integration**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- To introduce the concepts of measure and integral with respect to a measure, to show their basic properties, and to provide a basis for further studies in Analysis, Probability, and Dynamical Systems.
- To gain understanding of the abstract measure theory and definition and main properties of the integral.
- To construct Lebesgue's measure on the real line and in n-dimensional Euclidean space.
- To explain the basic advanced directions of the theory.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- derives the concepts of Borel sets, measurable functions, differentiation of monotone functions.
- analyze about the integral of simple functions, a non-negative function, functions of bounded variation.
- construct a clear idea about differentiation of an integral, absolute continuity and convex functions.
- apply the theory of the course to solve a variety of problems at an appropriate level of difficulty.

Syllabus

UNIT-1: Lebesgue Measure and measurable functions: Lebesgue Measure - Introduction, Outer measure, measurable sets and Lebesgue measure, translation invariant, algebra of measurable sets, countable subadditivity, countable additively and continuity of measure, Borel sets, a non- measurable set. Measurable Function -Examples: Characteristic function, constant function and continuous function, Sums, products and compositions, Sequential point wise limits, Simple functions.

UNIT-2: Lebesgue Integral of Bounded Functions: The Riemann integral, integral of simple functions, integral of bounded functions over a set of finite measure, bounded convergence theorem.

UNIT-3: The General Lebesgue Integral: Lebesgue integral of measurable nonnegative functions, Fatou's lemma, Monotone convergence theorem, the general Lebesgue integral, integrable functions, linearity and monotonicity of integration, additivity over the domains of integration. Lebesgue dominated convergence theorem.

UNIT-4: Differentiation and Integration: Differentiation of monotone functions, Vitali covering lemma, Dini derivatives, Lebesgue differentiation theorem, functions of bounded variation, Jordan's theorem, differentiation of an integral, indefinite integral, absolute continuity.

REFERENCES:

1. H. L. Royden: Real Analysis, 3d Edition, MacMillan, New York, 1963.
2. C. Goffman: Real Functions, Holt, Rinehart and Winston Inc. New York, 1953.
3. P. K. Jain and V. P. Gupta: Lebesgue Measure and Integration, Wiley Eastern Ltd., 1986.
4. I. K. Rana: An introduction to Measure and Integration, Narosa Publishing House, 1997.
5. G. DeBarra: Measure and Integration, Wiley Eastern Ltd., UK, 1981.
6. I. K. Rana : An Introduction to Measure and Integration, Narosa Publishing House, New Delhi, 1997.
7. P. R. Halmos: Measure Theory, Springer-Verlag, New York, 1974.
8. W. Rudin : Real & Complex Analysis, McGraw Hill, New York, 1987.

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.2	**Functional Analysis**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Students will learn the basic concepts and theorems of functional analysis and its applications.
- The student is able to apply knowledge of functional analysis to solve mathematical problems.
- The student is able to apply knowledge of theorems to solve basic problems.
- To gain understanding of the functional analysis and definition and main properties.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- describe properties of normed linear spaces and construct examples of such spaces.
- understand the Hahn-Banach theorems, the Open Mapping Theorem and its applications.
- apply basic theoretical techniques to analyze linear functionals and operators on Banach and Hilbert spaces.
- obtain Orthogonal complements, Orthonormal sets and conjugate space.

Syllabus

Unit I: Norm on a linear space over F (either R or C), Banach space. Examples. Norm on quotient space. Continuous linear transformation of normed linear space. The Banach space $B(N, N')$ for Banach spaces, N, N′ .

Unit II: Dual space of a normed linear space. Equivalence of norms. Dual space of C[a, b]. Isometric isomorphisms. Hahn –Banach theorem and its applications. Separable normed linear spaces.

Unit III: Canonical embedding of N into N**. Reflexive spaces, Open mapping theorem, closed graph theorem, principle of uniform boundedness (Bancah – Steinhaus theorem) projection on Banach spaces.

Unit- IV: Hilbert spaces: definition and examples. Orthogonal complements. Orthonormal basis, Gram – Schmidt process of orthonormalization. Bessel’s inequality, Riesz – Fisher theorem. Adjoint of an operator. Self – adjoint, normal, unitary and projection operators.

REFERENCES:

1. G. F. Simmons: *Introduction to Topology and Modern Analysis*, McGraw Hill Book Com. Inc.,1963.
2. C. Goffman and G. Pedrick: *First Course in Functional Analysis*, Prentice Hall of India Pvt. Ltd. New Delhi (1974)
3. B. V. Limaye: *Functional Analysis*, 2nd Edition, New Age International (P) Ltd. Publications (1997)
4. D. Somasundaram: *Functional Analysis*, S. Vishwanathan (Printers & Publishers) Pvt. Ltd. (1994)

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.3	**Operations Research**	4	70	30	100	4	3

Course Objective(s):

- To enable the students understand several concepts of Operations Research and its applications
- To enable the students to solve LPPs through various methods such as, graphical method, simplex method etc.
- To enable the student's formulation of dual LPP and duality theorems.
- To enable the students to analysis and solve transportation and assignment problems, game theory and CPM - PERT methods.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- apply the knowledge of basic optimization techniques in order to get best possible results from a set of several possible solution of different problems viz. linear programming problems, transportation problem, assignment problem and unconstrained and constrained problems etc.
- formulate an optimization problem from its physical consideration.
- understand the ideas of transportation and assignment problems.
- analyze the ideas of CPM and PERT in Network analysis.

Syllabus

UNIT-1: Linear Programming: Introduction, Formulation of LPP, General mathematical model of LPP. Slack and Surplus variables, canonical and standard form of LPP, Graphical method, standard LPP and basic solution, fundamental theorem of LPP, Simplex Algorithm, Big-M method and Revised Simplex Algorithm.

UNIT-2: Concept of duality: Formulation of dual LPP, duality theorem, advantages of duality, dual simplex algorithm and sensitivity analysis.

UNIT-3: Transportation and Assignment Problem: Transportation problem - Introduction, transportation problem, loops in transportation table, methods for finding initial basic feasible solution, tests for optimality, unbounded transportation problem. Assignment problem -mathematical form of the assignment problem, methods of solving assignment problem, variations of the assignment problem.

UNIT-4: Game Theory and Queuing Theory: Introduction, 2x2 game, solution of game, network analysis by linear programming, Brow's Algorithm. Shortest route and maximal flow problems, CPM and PERT. Introduction to Stochastic process, Markov chain, t.p.m., c-k equations, poisson process, birth and death process, concept of queues, Kendall's notation, m/m/1, m/m/s queues and their variants.

REFERENCES:

1. H. M. Wagner, *Principles of Operations Research*, Prentice Hall
2. J. K. Sharma, *Operations Research* : Theory and Application, Mcmillan

3. Man Mohan, P. K. Gupta, SwarupKanti, *Operation Research*, S. Chand Sons

4. S. D. Sharma, Operations Research (Theory.Meth& App), KedarNath Publishers.

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.4	**(a) Riemannian Geometry**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- The course introduces the fundamentals of differentiable manifolds and theory of Riemannian geometry.
- To familiarize the students with basic concepts of key notions in Riemannian metric tensor, Riemannian connection, geodesics, curvatures and hyper surfaces.
- To develop the problem-solving skills arising in geometry by using the techniques of differential calculus and integral calculus.
- To understand the idea of differentiable Manifolds, tangent vectors and tangent spaces.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- to formulate central theorems in Riemannian geometry and topology, and be able to give an account of their proofs.
- understand Riemannian manifolds with basic examples of Riemannian metrics, Levi-Civita connection.
- get introduced to the concepts of Weingarten map, Geodesics, Metric structure of Riemannian Manifold.
- get knowledge towards the Riemannian Christoffel curvature, tensors and sectional curvatures.

Syllabus

UNIT-1: Differentiable Manifolds: Definition of Differentiable Manifolds, Examples of differentiable manifolds, differentiable (smooth) functions, local coordinate system, differentiable mappings, tangent vectors and tangent spaces, vector fields, Jacobian of derivative map. Lie bracket. Immersion and Imbedding of manifolds, sub-manifolds.

UNIT-2: Riemannian Manifolds: Riemannian metric, Riemannian manifold and maps, Riemannian manifold as metric space, Groups and Riemannian manifolds, Local representation of metrics. Connections, the connections in local coordinates, Riemannian connections.

UNIT-3: Curvature: Curvature, fundamental curvature equations: Gauss and Codazzi-Mainardi equations; Tangential curvature equation, normal or mixed curvature equations, some Tensor concepts, Riemannian curvature, Riemannian Christoffel curvature tensors and sectional curvature. Fundamental theorem of Riemannian Geometry.

UNIT-4: Hypersurface: Gauss Map, Weingarten map, Existence of Hypersurface, Fundamental theorem of Hypersurface theory and Gauss Bonnet Theorem. **Geodesics:** Partials, Mixed partials, Geodesics, Metric structure of Riemannian Manifold, Gauss Lemma.

REFERENCES:

1. T. J. Willmore; Riemannian geometry, Oxford Science Publication, 1993.
2. W. M. Boothby; An Introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, revised, 2003.
3. U. C. De, A. A. Sheikh; Differential Geometry of Manifolds, Narosa Publishing House, 2007.
4. R. S. Mishra, A course in Tensors with Applications to Riemannian Geometry, Pothishala, Pvt. Ltd., Allahabad, 1965.
5. P. Peterson; Riemannian Geometry, Springer, 2006.
6. K. Yano; The Theory of Lie derivatives and its Applications, North Holland Publishing Company, Amsterdom, 1957.
7. M. P. do Carmo; Riemannian Geometry, Berkhauser, 1992.

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.4	**(b) Nevanlinna Theory**	**4**	**70**	**30**	**100**	**4**	**3**

Course Objective(s):

- Students will learn basics of entire and meromorphic function.
- Students will learn Poisson-Jenson's Theorem.
- Students will learn Characteristic function of Meromorphic functions.
- Students will learn fundamental theorems of Nevanlinna theorem.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- find the order and type of entire and meromorphic functions.
- know utility of Poisson-Jenson's theorem.
- write proofs of fundamental theorems of Nevanlinna Theory.
- know properties of deficient values and relation between various exponential functions.

Syllabus

Unit I : Basic Properties of Entire Functions. Order and Type of an Entire Function. Relationship between the order of an entire function and its derivative. Poisson Integral Formula. Poisson-Jenson Theorem. Exponent of Convergence of Zeros of an Entire function. Picard and Borel's Theorems for Entire Functions.

Unit II: Asymptotic values and Asymptotic Curve. Connection between Asymptotic and various Exponential Values.

Unit III: Meromorphic functions. Nevanlinna's Characteristic function. Cartan's Identity and Convexity theorems. Nevanlinna's First and second fundamental theorems. Order and type of meromorphic function. Order of a meromorphic function and its derivative. Relationship between $T(r,f)$ and $\log M(r,f)$ for an Entire Function. Basic Properties of $T(r,f)$.

Unit IV: Deficient Values and Relation between the Various Exponential Values. Fundamental Inequality of Deficient Values. Some Applications of Nevanlinna's Second Fundamental Theorem. Functions taking the same values at the same points. Fix-points of Integral Functions.

REFERENCES:

1. A. I. Markushevich: Theory of Functions of Complex Variable, Vol. –II, Prentice – Hall (1965)
2. A. S. B. Holland: Introduction to the theory of Entire Functions, Academic Press, New York (1973)
3. C. L. Siegel: Nine Introductions in Complex Analysis, North Holland (1981)
4. W. K. Hayman: Meromorphic Functions, Oxford University Press (1964)
5. Yang Lo: Value Distribution theory, Springer Verlag, Scientific Press (1964)
6. I. Laine: Nevanlinna Theory and Complex Differential Equations, Walter De Gruyter, Berlin (1993).

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.4	(c) Ring Theory	4	70	30	100	4	3

Course Objective(s):

- Students will learn Rings, definition properties and examples.
- Students will learn definition of modules , isomorphisms of modules and important theorem as Jordan- Holder Theorem
- Students will learn the ring Mn (R) of nxn matrices over a ring R and basic properties
- Noetheriam and Artinian rings and different applicable theorems

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- derive the Rings, definition properties and examples using various properties.
- construct Module, submodule, factor module using various properties.
- find out the Ideals in matrix ring, ring with matrix units. Simple rings. Jacobson radical J (R) of a ring and their basic properties.
- derive important theorems like Levitzki's theorem, Wedderburn theorem and Birkhoffs theorem.

Syllabus

Unit I: Ring, subring, left ideal, right ideal, ideal, factor ring-definition and examples. Ring homomorphism, isomorphism theorems, correspondence theorem.

Unit II: Module, submodule, factor module-definition and examples. Homomorphisms of modules, isomorphism theorems, correspondence theorem. Simple module, Schur's lemma. Noetherian, Artinian modules, composition series of modules, Jordan-Holder theorem, modules of finite length.

Unit III: The ring M_n(R) of nxn matrices over a ring R. Ideals in matrix ring, ring with matrix units. Simple rings. Jacobson radical J (R) of a ring. Basic properties. Prime ring semiprime ring, right primitive ring, Jacobson's density theorem. Prime ideal, semiprime ideal.

Unit IV: Noetheriam and Artinian rings, Levitzki's theorem. Wedderburn theorem for division rings. Lower nilradeal, upper nilradieal. Levitzki's radical of a ring. Subdirect product of rings, sub directly irreducible ring, Birkhoffs theorem.

REFERENCES:

1. C. Musili: Introduction to rings and Modules, 2nd Revised Edition, Narosa Publishing House (1994).
2. N. H. McCoy: Theory of rings, MacMillan Co. (1964).
3. T. Y. Lam: A First Course in Noncommulative Ring Theory, Graduate Text in Mathematics, No. 131, Springer – Verlag (1991).
4. L. H. Rowen: Ring Theory, Vol. – I, Academic Press (1988).

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.5	(a) Fluid Mechanics – II	4	70	30	100	4	3

Course Objective(s):

- Students will learn the basic concepts of boundary layer theory and its applications
- Students will learn the fundamentals of Magnetohydrodynamics, which include theory of Maxwell's equations, basic equations, exact solutions and applications of classical MHD.
- Give students practice in concepts of dimensional analysis and problem solving.
- Students will learn the applications of Magnetohydrodynamics in daily life.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- understand the concept of boundary layer theory and its applications
- provide the details of the derivation of ideal and resistive MHD equations.
- demonstrate the basic properties of ideal MHD.
- provides a theoretical and practical background to Ph.D. thesis in heat transport and stellar atmosphere models.

Syllabus

UNIT – I: Theory of laminar boundary layer concepts : Definition of laminar and turbulent, Two dimensional boundary layer equations for flow over a plane wall, Prandtl,s boundary layer concept, some definition of boundary layer thickness, displacement thickness, momentum thickness. Boundary layer flow along a flat plate- Blasius solution.

UNIT – II: Basic equations of MHD: Outline of basic equations of MHD, (i) Conservation of mass (ii) Conservation of momentum. Lagrangian approach and Eularian approach. Magnetic Induction equation, Lorentz force. Exact Solutions: Hartmann flow, isothermal boundary conditions, Temperature distribution in Hartmann flow, Hartmann-Couette flow.

UNIT – III: Dimensional analysis: Dimensional homogeneity, Rayleigh's technique, Buckingham π- theorem, model analysis and dynamical similarity, Reynolds's number, significance of Reynold's number. Some useful dimensionless number: (i) Reynolds's number and magnetic Reynolds's number (ii) Froude number (ii) Euler number (iv) Mach number (v) Prandtl number and magnetic Prandtl number (vi) Eckert number.

UNIT – IV: Convective instability: Basic concepts of convective instability, Rayleigh Bénard convection, Boussinesq approximation, equation of state, perturbed state, normal modes, principle of exchange of stabilities, first variation principle, different boundary conditions on velocity and temperature, solution for free-free boundaries.

REFERENCES:

1. Schlichting H., Boundary layer theory, McGraw-Hill, 1979.
2. Lin C. C., The theory of Hydrodynamic stability, Cambridge University Press, 1955.
3. Chandrasekhar S., Hydrodynamic and Hydrodynamic stability, Oxford University Press. 1961.
4. G. K. Bachelor: An Introduction to Fluid Mechanics, Foundation Books, New Delhi, (1994).
5. D. J. Tritton, Physical fluid dynamics, Oxford Science publication, second edition, 1987.
6. Nield D. A. and Bejan A., Convection in porous media, Springer, 2006.
7. F. Chorlton: Text Book of Fluid Dynamics, CBS Publishers, New Delhi, (1985).
8. R. K. Rathy: An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, (1976).

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.5	(b) Classical Mechanics	4	70	30	100	4	3

Course Objective(s):

- To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics.
- To represent the equations of motion for complicated mechanical systems using the Lagrangian and Hamiltonian formulation of classical mechanics.
- Students will learn the applications of Magnetohydrodynamics in daily life.
- To develop skills in formulating and solving physics problems

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- demonstrate the knowledge of core principles in mechanics.
- interpret complex and difficult problems of classical dynamics in a systematic way.
- apply the variation principle for real physical situations.
- identify the existing symmetries and the corresponding integrals of motion and analyze the qualitative nature of dynamics.

Syllabus

UNIT I: Analytical dynamics: Generalized Co-ordinates, Holonomic and non- Holonimic systems. Seleronomic and Rheonomic systems. D'Alembert's principle and Lagrange's equation from D'Alembert's principle. Velocity dependent potentials and the dissipation function. Energy equation for conservative field. Generalized momenta and Hamilton's canonical equations. Rigid body and Eulerian angles, infinitesimal rotations. Coriolis theorem. Motion relative to rotating earth. Euler's dynamics equations of Motion of a symmetrical top.

UNIT II : Hamilton's principle of least action. Deduction of Lagrange and Hamilton equation from Hamilton's principle. Hamilton's variational principle. Poincare integral invariants. Whittaker's equation, Jacobi's equations, statement of Lee Hwa Chung's theorem, Hamilton- Jacobi's equation and it's complete integral. Solution of Harmonic oscillator problem by Hamilton-Jacobi method.

UNIT III : Cyclic Co-ordinates, Routh's equation, Poisson's identity, Lagrange's Bracket condition of canonical character of transformation in term of Lagrange's Bracket. Poisson's bracket. Invariance of Lagrange's brackets and Poisson brackets under canonical transformations.

UNIT IV : Motivation problems of calculus of variations. Shortest distance. Maximum surface of revolution. Brachistochrome problem, Geodesic. Fundamental lemma of calculus of variations. Euler's equation for one independent function and its generalization to (a) 'n' independent function (b) higher order derivatives. Conditional extremum under geometry constraints and under integral constraints.

REFERENCES:

1. A.S. Ramsey, Dynamics Part II, The English Language Book society and Cambridge University Press, (1972)
2. F.Gantmacher, Lectures in Analytical Mechanics, MIR PUBLISHER, Mascow, 1975
3. H.Goldstein, Classical Mechanics (2nd edition), Narosa Publishing house,New Delhi.
4. I.M.Gelfand and S.V.Fomin, Calculus of Variations, Prentice Hall.
5. Narayan Chandra Rana and Sharad Chandra Joag.Classical Mechanics, Tata McGraw Hill. 1991
6. Louis N.Hand and Janet D.Finch, Analytical Mechanics, Cambridge University Press. 1998.

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	MT4.5	c) Mathematical Methods	4	70	30	100	4	3

Course Objective(s):

- ➢ Understand the concepts of Asymptotic expansion of functions, power series as asymptotic series, asymptotic forms for large and small variables.
- ➢ Find the solutions for Linear equation with variable coefficients and nonlinear BVP's.
- ➢ Problems involving Boundary layers.
- ➢ Providing a set of powerful analytical tools for the solution of problems.

Course Outcome(s):

Upon the successful completion of the course, students will be able to

- recognize the different methods of finding solutions for integral equations by separable kernel, Neumann's series resolvent kernel and transform methods.
- apply the knowledge of Integral Equations and Integral transforms in finding the solutions of differential equations, initial value problems and boundary value problems.
- perform analysis on Regular and singular perturbation methods.
- perform analysis of first and second order differential equations involving constant and variable coefficients.

Syllabus

Unit – I: Integral Transforms: General definition of integral transforms, Kernels, etc. Hankel transforms to solve ODEs and PDEs - typical examples. Discrete Orthogonality and Discrete Fourier transform. Wavelets with examples, wavelet transforms.

Unit – II: **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. Hilbert Schmidt theorem, Raleigh Ritz and Galerkin methods.

Unit – III: 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.

Unit – IV: Perturbation methods: 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.

REFERENCES:

1. IN Sneddon: *The use of Integral Transforms*, Tata Mc Graw Hill, Publishing Company Ltd, New Delhi,1974.
2. R.P.Kanwal:*Linearintegralequationstheory&techniques*,AcademicPress,NewYork,1971.
3. C.M. Bender and S.A. Orszag: *Advanced mathematical methods for scientists and engineers*, Mc Graw Hill, New York,1978.
4. H.T. Davis: *Introduction to nonlinear differential and integral equations*, Dover Publications, 1962.
5. A.H.Nayfeh:*PerturbationMethods*,JohnWiley&Sons,NewYork,1973.
6. D. Hong, J. Wang and R. Gardner: *Real analysis with introduction to wavelets and applications*, Academic Press Elsevier(2006)
7. R.V. Churchill: *Operational Mathematics*, Mc. Graw Hill, New York,1958.

I Semester M.Sc. Examination, December, 2020
(2020-21 CBCS; New Syllabus)
MATHEMATICS
MT1.1: Algebra

Time: 3 Hours **Max. Marks: 70**

Note: *Part-**A** is compulsory, **four** questions from Part-**B** and **four full** questions from Part-**C***

PART – A

1. Answer **any five** of the following: **(2×5 = 10)**

a)

b)

c)

d)

e)

f)

g)

PART – B

(5×4 = 20)

2.

3.

4.

5.

6.

7.

PART – C

(10×4 = 40)

8.

9.

10.

11.

12.

13.