

# RAICHUR UNIVERSITY

YERAGERA - 584133, RAICHUR, INDIA.

RAICHUR  
UNIVERSITY



**SYLLABUS  
FOR**

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

**MATHEMATICS**

**With effect from 2023-24 & onwards**

## **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.
- pursue 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 (2023-24& Onwards)**

	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
<b>SEMESTER - I</b>	<b>HARD CORE PAPERS</b>							
	HCT 1.1	Algebra	4	80	20	100	4	3
	HCT1.2	Real Analysis – I	4	80	20	100	4	3
	HCT1.3	Discrete Mathematics & C-Proramming	4	80	20	100	4	3
	HCT 1.4	Ordinary DifferentialEquations	4	80	20	100	4	3
	<b>SOFT CORE PAPER (ANY ONE)</b>							
	SCT 1.1	Operations Research	4	80	20	100	4	3
		Fuzzy Sets & Fuzzy Logic						
	<b>PRACTICAL</b>							
	HCP 1.1	Programming Lab-I	4	40	10	50	2	3
<b>Mandatory Credits: English Language Communication Skill</b>			2	---	---	---	2	---
<b>SEMESTER - II</b>	<b>HARD CORE PAPERS</b>							
	HCT 2.1	Linear Algebra	4	80	20	100	4	3
	HCT 2.2	Real Analysis – II	4	80	20	100	4	3
	HCT 2.3	General Topology	4	80	20	100	4	3
	HCT 2.4	Partial Differential Equations	4	80	20	100	4	3
	<b>SOFT CORE PAPER (ANY ONE)</b>							
	SCT 2.1	Graph Theory	4	80	20	100	4	3
		Classical Mechanics						
	<b>PRACTICAL</b>							
	HCP 2.1	Programming Lab – II	4	40	10	50	2	3
<b>OPEN ELECTIVE PAPER (ANY ONE)</b>								
OET 2.1	Foundations of Mathematics	2	40	10	50	2	3	
	Financial and Business Mathematics							
<b>Mandatory Credits: Computer Skill</b>			2	---	---	---	2	---
<b>SEMESTER - III</b>	<b>HARD CORE PAPERS</b>							
	HCT 3.1	Measure Theory and Integration	4	80	20	100	4	3
	HCT 3.2	Complex Analysis – I	4	80	20	100	4	3
	HCT 3.3	Fluid Mechanics	4	80	20	100	4	3
	HCT 3.4	Numerical Methods – I	4	80	20	100	4	3
	<b>SOFT CORE PAPER (ANY ONE)</b>							
	SCT 3.1	Advanced Topology	4	80	20	100	4	3
		Number Theory						
	<b>OPEN ELECTIVE PAPER (ANY ONE)</b>							
	OET 3.1	Statistical Techniques	2	40	10	50	2	2
Elements of Applied Mathematics								
<b>PRACTICAL PAPER</b>								
HCP 3.1	Programming Lab – III	4	40	10	50	2	3	
<b>Mandatory Credits: Personality Development</b>			2	---	---	---	2	---

<b>SEMESTER - IV</b>	<b>HARD CORE PAPERS</b>							
	<b>HCT 4.1</b>	Functional Analysis	4	80	20	100	4	3
	<b>HCT 4.2</b>	Complex Analysis – II	4	80	20	100	4	3
	<b>HCT 4.3</b>	Differential Geometry	4	80	20	100	4	3
	<b>HCT 4.4</b>	Numerical Methods-II	4	80	20	100	4	3
	<b>SOFT CORE PAPER (ANY ONE)</b>							
	<b>SCT 4.1</b>	Magnetohydrodynamics	4	80	20	100	4	3
		Mathematical Methods						
	<b>PROJECT WORK/REPORT WRITING</b>							
	<b>HCP 4.1</b>	Project	4	80	20	100	4	3
<b>Total Credits for the Course</b>		<b>106</b>	<b>---</b>	<b>---</b>	<b>2350</b>	<b>100</b>	<b>---</b>	



	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)	
				Examination	Internal Assessment	Total Marks			
<b>SEMESTER - I</b>	<b>HARD CORE PAPERS</b>								
	HCT 1.1	Algebra	4	80	20	100	4	3	
	HCT1.2	Real Analysis - I	4	80	20	100	4	3	
	HCT1.3	Discrete Mathematics & C-Proramming	4	80	20	100	4	3	
	HCT 1.4	Ordinary DifferentialEquations	4	80	20	100	4	3	
	<b>SOFT CORE PAPER (ANY ONE)</b>								
	SCT 1.1	Operations Research		4	80	20	100	4	3
		Fuzzy Sets & Fuzzy Logic							
	<b>PRACTICAL</b>								
	HCP 1.1	Programming Lab-I		4	40	10	50	2	3
Mandatory Credits: English Language Communication Skill			2	---	---	---	2	---	

### HARD CORE PAPERS

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT 1.1	Algebra	4	80	20	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.

**UNIT- III:** Rings-Homomorphism, Kernel, 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, Eisenstein 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, Perfect Fields, Normal extension.

## REFERENCES:

1. I. N. Herstein: *Topics in Algebra* 2nd edition, John Wiley and Sons, New York, 1975
2. Surjeet Singh and Qazi Zameeruddin: *Modern Algebra*, 8<sup>th</sup> Edition, vikas Publishing House pvt.ltd, 2006.
3. M. Artin : *Algebra*, Prentice hall, Upper Saddle River, New Jersey, 1991
4. K. Ciesielski,: *Set Theory for the Working Mathematician*, Cambridge University Press, Cambridge, 1997.
5. Hall and Knight: *Higher Algebra* 6th edition, Arihant Publications, India, 2016.
6. S. K. Jain, P. B. Bhattacharya and S. R. Nagpaul: *Basic Abstract Algebra*, Cambridge University Press, Cambridge, 1997.
7. S. Singh and Q. Zameeruddin: *Modern Algebra*, Vikas Publishing House, India, 1975
8. S. M. Srivatsava: *A Course on Borel Sets*, Springer- Verlag, New York, 1998.
9. 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		
	HCT1.2	Real Analysis - I	4	80	20	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		
	HCT1.3	Discrete Mathematics & C-Programming	4	80	20	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 functions.

**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, Goto statement.

**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. Bondy 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		
	HCT1.4	Ordinary Differential Equations	4	80	20	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 Wiley and Sons, 2002.
8. F. Ayers, *Theory and problems of differential equations*, McGraw Hill, 1972.

### SOFT CORE PAPER (ANY ONE)

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	SCT 1.1	Operations Research	4	80	20	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-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	<b>SCT 1.1</b>	<b>Fuzzy Sets &amp; Fuzzy Logic</b>	<b>4</b>	<b>70</b>	<b>30</b>	<b>100</b>	<b>4</b>	<b>3</b>

### 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  $\alpha$  - cuts, strong  $\alpha$  - 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.  $\alpha$  - shading families,  $\alpha$  - connectedness and  $\alpha$  - 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)

### PRACTICAL PAPER

Semester-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	SCP 1.1	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 SCT 1.4 (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			
<b>SEMESTER - II</b>	<b>HARD CORE PAPERS</b>								
	HCT 2.1	Linear Algebra	4	80	20	100	4	3	
	HCT 2.2	Real Analysis - II	4	80	20	100	4	3	
	HCT 2.3	General Topology	4	80	20	100	4	3	
	HCT 2.4	Partial Differential Equations	4	80	20	100	4	3	
	<b>SOFT CORE PAPER (ANY ONE)</b>								
	SCT 2.1	Graph Theory		4	80	20	100	4	3
		Classical Mechanics							
	<b>PRACTICAL</b>								
	HCP 2.1	Programming Lab - II		4	40	10	50	2	3
	<b>OPEN ELECTIVE PAPER (ANY ONE)</b>								
	OET 2.1	Foundations of Mathematics		2	40	10	50	2	3
Financial and Business Mathematics									
<b>Mandatory Credits: Computer Skill</b>			2	---	---	---	2	---	

### HARD CORE PAPERS

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT2.1	Linear Algebra	4	80	20	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 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. I. N. Herstein: *Topics in Algebra* 2nd edition, John Willey and Sons, New York, 1975.
2. W. C. Brown: *A Second Course in Linear Algebra*, John Willey and Sons, New York, 1988.
3. W. Cheney and D. Kincaid: *Linear Algebra*, Jones and Bartlett Publishers, Canada, 2010.
4. J. Hefferon: *Linear Algebra* 3rd edition, Joshua publication, Colchester, Vermont USA, 2017.
5. K. Hoffman and R. Kunze: *Linear Algebra* 2<sup>nd</sup> edition, Prentice Hall, India, 2001.
6. V. K. Khanna & S. K. Bhamri: *A Course in Abstract Algebra*, 4<sup>th</sup> edition, Vikas Publication, India, 2013
7. 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		
	HCT2.2	Real Analysis - II	4	80	20	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 Uniform 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, equicontinuous families of functions: point wise and uniformly bounded, equicontinuous 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		
	HCT 2.3	General Topology	4	80	20	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 subbasis, 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  $\mathbb{R}$ , open and closed maps, homeomorphisms, finite product spaces, projection maps.

**Unit III: Connectedness:** Connected and disconnected spaces, separated sets, intermediate value theorem, components, local connectedness, path connectedness.

**Unit IV: Compactness:** Cover, subcover, compactness, characterizations, invariance of compactness under maps, properties.

**References:**

1. James. Dugundji: *Topology*, 1<sup>st</sup> edition, Allyn and Bacon, Inc., 1966.
2. J. R. Munkres: *Topology- A first course*, 2<sup>nd</sup> 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 Mathematics series, Springer-Verlag, New York, 1995.
8. C. W. Baker: *Introduction to topology*, Brown (William C.) Co, U.S., 1991.

Semester-II	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT2.4	Partial Differential Equations	4	80	20	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. Trèves: *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, New Delhi, 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).

## SOFT CORE PAPER (ANY ONE)

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	SCT 2.1	Advanced Graph Theory	4	80	20	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. Kuratowaskicriterionplanarity 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: Automorphisin group of a graph, operation on permutation graphs and composition of graphs.

**REFERENCES:**

1. M. Behzad, G.ChartrandandL. Lesniak:*GraphsandDiagraphs*, 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. DoobandH.Sachs:*SpectrainGraphs*,AcademicPress,NewYork, 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, 1969.
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-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	SCT 2.1	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-Holonomic systems. Scleronomic 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 its 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. Brachistochrone 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, Moscow, 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-I	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	SCP 2.1	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 softwares like Mathematica, Matlab to solve various mathematical problems.
- understand the use of various techniques of the softwares for effectively doing mathematics.
- obtain necessary skills in programming to solve ODEs.
- understand the applications of applied mathematics.

### Syllabus

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

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	OET 2.1	<b>Foundations of Mathematics (Interdisciplinary-Elective paper)</b>	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		
	OET 2.1	<b>Financial and Business Mathematics (Interdisciplinary-Elective paper)</b>	2	40	10	50	2	2

**Course Objective(s):**

- To enable students to understand fundamentals of operations of mathematics in real world life.
- 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

- Evaluate business problems involving complex linear relationships between decision variables and their determining factors.
- Explain mathematical formulation and solution of problems related to finance including different methods of interest calculation, future and present value of money

**Units 1: Ratio, Proportion and Percentage**

Ratio- Definition, Continued ratio, Inverse Ratio, Proportion - Continued proportion, Direct proportion, Inverse proportion, Variation - Inverse variation, Joint variation Percentage- Meaning and computation of percentage

**Unit 2: Profit and Loss**

Terms and formulae, Trade discount, Cash discount, problems involving cost price, selling price, trade discount, cash discount. Introduction to Commission and brokerage – problems on commission and brokerage

**Unit 3: Interest and Annuity**

Simple interest, compound interest, Equated monthly instalments, reducing balance and flat rate of interest Annuity immediate- present value and future value Stated annual rate and effective annual rate

#### Unit 4: Shares and Mutual Fund

Shares- Concept, face value, market value, dividend, Equity shares, preference shares, bonus shares, Mutual Fund- Simple problems on calculation of net income after considering entry load, exit load, dividend, change in net asset value

#### REFERENCES:

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



	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
SEMESTER - III	<b>HARD CORE PAPERS</b>							
	HCT 3.1	Measure Theory and Integration	4	80	20	100	4	3
	HCT 3.2	Complex Analysis - I	4	80	20	100	4	3
	HCT 3.3	Fluid Mechanics	4	80	20	100	4	3
	HCT 3.4	Numerical Methods - I	4	80	20	100	4	3
	<b>SOFT CORE PAPER (ANY ONE)</b>							
	SCT 3.1	Advanced Topology Number Theory	4	80	20	100	4	3

OPEN ELECTIVE PAPER (ANY ONE)							
OET 3.1	Statistical Techniques	2	40	10	50	2	2
	Elements of Applied Mathematics						
PRACTICAL PAPER							
HCP 3.1	Programming Lab - III	4	40	10	50	2	3
Mandatory Credits: Personality Development		2	---	---	---	2	---

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT3.1	Measure Theory and Integration	4	80	20	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 functions, 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 additivity 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. G. DeBarra: Measure and Integration, Wiley Eastern Ltd., UK, 1981.
3. C. Goffman: Real Functions, Holt, Rinehart and Winston Inc. New York, 1953.
4. P. K. Jain and V. P. Gupta: Lebesgue Measure and Integration, Wiley Eastern Ltd., 1986.
5. I. K. Rana: An introduction to Measure and Integration, Narosa Publishing House, 1997.
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-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT 3.2	Complex Analysis - I	4	80	20	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. Harmonic 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, Rouché's theorem and its applications.

**References:**

1. J. B. Conway: *Functions of One Complex Variable*, 2<sup>nd</sup> edition, Graduate Texts in Mathematics, Springer-Verlag, New York–Berlin, 1978; first edition, 1973.
2. Ahlfors, L. V.: *Complex Analysis*, 3<sup>rd</sup> edition, New York, McGraw-Hill, 1979.
3. S. Ponnusamy: *Foundations of Complex Analysis*, 2<sup>nd</sup> Edition, Narosa Publishing House, India, 2005.
4. R. V. Churchill and J. W. Brown: *Complex Variables and Applications*, 4<sup>th</sup> 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*, 2<sup>nd</sup> edition, PHI Learning Pvt. Ltd., India, 2005.
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Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	<b>HCT3.3</b>	<b>Fluid mechanics</b>	<b>4</b>	<b>80</b>	<b>20</b>	<b>100</b>	<b>4</b>	<b>3</b>

**Course Objective(s):**

- To familiarize the students with basic concepts of fluid dynamics.
- To understand the applications in medical, astrophysical, geophysical, agricultural, aerodynamical 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-1: 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 equations in standard forms, Illustrative examples thereon, Vortex motion, Circulation, Kelvin’s circulation theorem, Helmholtz Vorticity equation, Performance in Vorticity and Circulation, Kelvin’s Minimum Energy Theorem, Illustrative examples.

**UNIT-2: 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 and Applications.

**UNIT-3: Motion of Viscous Fluids:** Stress tensor of viscous fluid flow, Stoke's law,

Navierstoke's equation, Simple exact solutions of the Navier-Stoke's equation, Standard applications, i) Plane Poiseuille and Hagen Poiseuille flows ii) Couette flow iii) Steady flow between concentric cylinders iv) Beltrami flows v) Unsteady flow near an oscillating plate vi) Slow and steady flow past a rigid sphere and cylinder. Diffusion of Vorticity, Energy dissipation due to Viscosity, Dimensional analysis (Brief discussion), Reynolds number, Laminar and Turbulent flows, Examples of flow at low and high Reynolds number, Brief discussion of boundary layer theory with illustrative examples.

**UNIT-4: Gas Dynamics:** Compressible fluid flows, Standard forms of equations of State, Speed of sound in a gas, Equations of motion of Non-Viscous and Viscous Compressible flows, Subsonic, Sonic and supersonic flows, Isentropic flows, Gas Dynamical Equations, Illustrative examples.

**References:**

1. G. K. Batchelor: 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. Landau and E. M. Lifschil: 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		
	HCT 3.4	Numerical Methods-I	4	80	20	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 Jacobi'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  $\delta^2$  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 Jacobi'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*, 2<sup>nd</sup> edition, Cambridge texts in applied mathematics, 2008.
7. D. Kincaid and W Cheney: *Numerical analysis*, 3<sup>rd</sup> edition American Mathematical Society, 2002.
8. R.L. Burden and J.D. Faires: *Numerical Analysis*, 7<sup>th</sup> 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		
	SCT3.1	Advanced Topology	4	80	20	100	4	3

**Course Objective(s):**

- Students will learn Countability axioms in topological spaces.
- Students will learn Metric spaces and metrizable 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 metrizable.
- 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 Metrizable:** Separation and countability axioms in metric spaces, convergence in metric spaces, complete metric spaces, Urysohn's Metrization theorem, Bing's Metrization theorem, Nagata-Smirnov Metrization 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		
	SCT 3.1	Number Theory	4	80	20	100	4	3

#### Course Objective(s):

- The course aims to give elementary ideas from number theory which will have applications in cryptology.
- Identify and apply various properties of and relating to the integers including the Well-Ordering Principle, primes, unique factorization, the division algorithm, understand the concept of a congruence,
- To impart the knowledge of encryption and decryption techniques and their applications in managing the security of data

#### Course Outcome(s):

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

- Solve problems in elementary number theory.
- At the end of the course the student will be able to go for higher courses in number theory.
- They will be more logical and careful in finding proofs of mathematical results.

#### Syllabus

**Unit I :** Prime numbers, The Fundamental theorem of Arithmetic, The series of Reciprocals of primes, The Euclidean Algorithm. Fermat and Mersenne numbers. Farey series, Farey dissection of the continuum, Irrational numbers-Irrationality of  $m$ th root of  $N$ ,  $e$  and  $\pi$ .

**Unit II:** Arithmetical Functions – The Mobius function, The Euler' function and Sigma function, The Dirichlet product of Arithmetical functions, Multiplicative functions. Averages of Arithmetical functions – Euler summation formula, Some elementary asymptotic formulas, The average orders of  $d(n)$ ,  $\sigma(n)$ ,  $\varphi(n)$ ,  $\mu(n)$ . An application to the distribution of lattice points visible from the origin.

**Unit III:** Approximation Irrational numbers, Hurwitz's Theorem, Representation of a number by two or four squares, Definition  $g(k)$  and  $G(k)$ , Proof of  $g(4) > 50$ , Perfect numbers. The series of Fibonacci and Lucas.

**Unit IV:** Continued fractions - Finite continued fractions, Convergent of a continued fraction, Continued fractions with positive quotients. Simple continued fractions, The representation of an irreducible rational fraction by a simple continued fraction. The continued fraction algorithm and Euclid's algorithm. The difference between the fraction and its convergents, Infinite simple continued fractions, the representation of an irrational number by an infinite continued fraction, Equivalent numbers and periodic continued fractions, some special quadratic surds.

**Reference:**

1. G. H. Hardy and E. M. Wright – An Introduction to Theory of Numbers, Oxford University Press, 1979, 5th Ed.,
2. I. Niven, H. S. Zuckerman and H. L. Montgomery – An Introduction to the Theory of Numbers, New York, John Wiley and Sons, Inc., 2004, 5th Ed.,
3. Bruce C. Berndt – Ramanujan's Note Books Volume-1 to 5, Springer.
4. G. E. Andrews – Number Theory, Dover Books, 1995.
5. T. M. Apostol – Introduction to Analytic Number Theory, Narosa Publishing House, New Delhi.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	OET 3.1	<b>STATISTICAL TECHNIQUES</b>	2	40	10	50	2	2

### Course Objective(s):

- To find the association between attributes.
- To find the correlation between two variables and form regression lines.
- To understand the concepts of sampling
- To estimate the parameters using various methods.
- To understand exact sampling distribution

### Course Outcome(s):

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

- Analyze the data pertaining to attributes and to interpret the results.
- To recognize and evaluate the relationship between two quantitative variables through simple linear correlation and regression.
- To understand the relationship between sample statistics and population parameters.

### Syllabus

**Unit I: Measure of Central Tendency:** Arithmetic mean, Median, Mode, Geometric mean and Harmonic mean, Merits and demerits.

**Unit II: Measure of Variation:** Introduction, mean deviation, Standard deviation, merits and limitations.

**Unit III: Correlation Analysis:** Types of Correlation, methods of studying correlation, Karl Person's co-efficient of correlation, Rank correlation co-efficient, methods of least squares. **Regression Analysis:** Introduction, Regression lines, Regression equations of Y on X, Regression Co-efficient.



**Unit IV: Probability:** Random experiment, Sample space and events, Axioms of probability, Conditional probability and independence, Addition, Multiplication and Baye's theorem.

**References:**

- 1.S.P. Gupta and M.P. Gupta, Business Statistics
2. C.B. Gupta, An Introduction to Statistical methods

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	<b>OET 3.1</b>	Elements of Applied Mathematics	<b>2</b>	<b>40</b>	<b>10</b>	<b>50</b>	<b>2</b>	<b>2</b>

**Course Objective(s):**

- To find the association between attributes.
- Students should be able to explain basic concepts of matrix theory, numerical techniques, probability distributions and calculus of single variable
- Students should be able to apply basic concepts of differential calculus to solve problems related to extremum, approximations, curvature etc

**Course Outcome(s):**

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

- Students should be able to apply basic numerical techniques to solve linear and nonlinear equations.
- Students should be able to do basic statistical inference, linear and nonlinear regression analysis and design of experiments.
- Students should be able to effectively choose appropriate mathematical and statistical concepts to solve various real world problems.

**Unit I:**Solutions of system of linear equations (Gauss-elimination, LU-decomposition etc.)  
Numerical methods for solving non-linear algebraic / transcendental etc.

**Unit II:**Newton's method, Secant, Regula Falsi, Jacobi

**Unit III:**Numerical solution set of linear algebraic equations: Jacobi, Gauss Siedel, and under / over relaxation methods

**Unit IV:** Interpolation and extrapolation for equal and non-equal spaced data (Newtons Forward, Newtons backward and Lagrange) Numerical integration (trapezoidal rule, Simpson's Rule)

**Reference:**

1. Erwin Kreyszig, John-Wiely , Advanced Engineering Mathematics.
2. S. R. K. Iyengar, R. K. Jain , Advanced Engineering Mathematics.
3. S. S. Sastry, Introductory Methods Of Numerical Analysis.

Semester-III	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	SCP 3.1	Programming Lab - III	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 representations 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 HCT 3.4 (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			
<b>SEMESTER - IV</b>	<b>HARD CORE PAPERS</b>								
	HCT 4.1	Functional Analysis	4	80	20	100	4	3	
	HCT 4.2	Complex Analysis - II	4	80	20	100	4	3	
	HCT 4.3	Differential Geometry	4	80	20	100	4	3	
	HCT 4.4	Numerical Methods-II	4	80	20	100	4	3	
	<b>SOFT CORE PAPER (ANY ONE)</b>								
	SCT 4.1	Magnetohydrodynamics		4	80	20	100	4	3
		Mathematical Methods							
	<b>PROJECT WORK/REPORT WRITING</b>								
	HCP 4.1	Project		4	80	20	100	4	3

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT4.1	Functional Analysis	4	80	20	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 (Banach – 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*, 2<sup>nd</sup> 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		
	HCT 4.2	Complex Analysis - II	4	80	20	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:** Weierstrass theorem, 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*, 2<sup>nd</sup> Edition, Narosa Publishing House, India, 2005.
4. R. V. Churchill and J. W. Brown: *Complex Variables and Applications*, 4<sup>th</sup> Edition, McGraw Hill Book Company, New York, 1984.
5. H. S. Kasana: *Complex Variables- Theory and Applications*, 2<sup>nd</sup> edition, PHI Learning Pvt. Ltd., India, 2005.
6. H. A. Priestley: *Introduction to Complex Analysis*, 2<sup>nd</sup> 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.



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Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT 4.3	Differential Geometry	4	80	20	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 evolutes 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, coordinate 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-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	HCT 4.4	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 1/3<sup>rd</sup> rule, Simpson's 3/8<sup>th</sup> 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<sup>nd</sup> 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<sup>nd</sup> edition, Cambridge texts in applied mathematics, 2008.
8. R.L. Burden and J.D. Faires: *Numerical Analysis*, 7<sup>th</sup> edition, Thomson-Brooks/Cole, 1989.

Semester-IV	Subject / Paper Code	Title of the Paper	Instruction Hrs/ Week	Marks			Credits	Examination duration (Hrs)
				Examination	Internal Assessment	Total Marks		
	SCT4.1	Magnetohydrodynamics	4	80	20	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 Eulerian 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  $\pi$ - 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. Batchelor: 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		
	SCT4.1	Mathematical Methods	4	80	20	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: *Linear integralequationstheory&techniques*, Academic Press, New York, 1971.
3. C.M. Bender and S.A.Orszag: *Advanced mathematical methods for scientists andengineers*, 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, New York, 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.

## Question Paper Pattern

I Semester M.Sc. Examination, December, 2020  
(2020-21 CBCS; New Syllabus)  
**MATHEMATICS**  
HCT 1.1 : Algebra

**Time: 3 Hours**

**Max. Marks: 80**

*Instructions to the candidates: 1) Answer any five full questions*

*2) All questions carry equal marks*

**16 X 5=80**

1. a)

b)

2. a)

b)

3. a)

b)

4. a)

b)

5. a)

b)

6. a)

b)

7. a)

b)

8. a)

b)



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