BHARATHIDASAN UNIVERSITY TIRUCHIRAPPALLI - 620 024

M.Sc. MATHEMATICS: CHOICE BASED CREDIT SYSTEM – LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK (CBCS - LOCF)

(Applicable to the candidates admitted from the academic year 2022-2023 onwards)

Sem	Course	Title	Ins. Hrs / Week	Credit	Exam Hrs	Marks		Total
						Int.	Ext.	
I	Core Course – I (CC)	Algebra	6	5	3	25	75	100
	Core Course – II (CC)	Real Analysis	6	5	3	25	75	100
	Core Course – III (CC)	Ordinary Differential Equations	6	5	3	25	75	100
	Core Choice Course – I (CCC) (any one title)	1. Classical Dynamics 2. Automata Theory	6	5	3	25	75	100
	Elective Course – I (EC)	Any one from the list	6	4	3	25	75	100
	TOTAL		**30**	**24**				**500**
II	Core Course – IV (CC)	Complex Analysis	6	5	3	25	75	100
	Core Course – V (CC)	Linear Algebra	6	5	3	25	75	100
	Core Choice Course – II(CCC) (any one title)	1. Partial Differential Equations 2. Nonlinear Differential Equations	6	5	3	25	75	100
	Elective Course – II (EC)	Any one from the list	6	4	3	25	75	100
	Non-Major Elective – I (NME)	Statistics	3	2	3	25	75	100
	Value-Added Course – I (VAC) (any one title)	1. Introduction to LATEX 2. Introduction to MATLAB	3	2*	3	40	60	100
	TOTAL		**30**	**21**				**500**
III	Core Course – VI (CC)	Topology	6	5	3	25	75	100
	Core Course – VII (CC)	Measure Theory and Integration	6	5	3	25	75	100
	Core Choice Course – III(CCC) (any one title)	1. Advanced Numerical Analysis 2. Algebraic Number Theory	6	5	3	25	75	100
	Elective Course – III (EC)	Any one from the list	6	4	3	25	75	100
	Non-Major Elective – II (NME)	Mathematics for Competitive Examinations	3	2	3	25	75	100
	Value-Added Course – II (VAC) (any one title)	1. Mathematics for Competitive Examinations 2. Introduction to Sagemath	3	2*	3	25	75	100
	TOTAL		**30**	**21**				**600**
IV	Core Course – VIII (CC)	Functional Analysis	6	5	3	25	75	100
	Core Course – IX (CC)	Differential Geometry	6	5	3	25	75	100
	Core Course – X(CC)	Fluid Dynamics	6	5	3	25	75	100
	Elective Course – IV (EC)	Any one from the list	6	4	3	25	75	100
	Project		6	5	-	20	80	100
	TOTAL		**30**	**24**				**500**
GRAND TOTAL			**120**	**90**				**2200**

***The value added courses credit will not be included in the total CGPA.**
These courses are extra-credit courses.
Instruction hours for these courses is 30 hours.

LIST OF ELECTIVE COURSES

Elective I		Elective II	
1	Graph Theory	1	Optimization Techniques
2	Discrete Mathematics	2	Mathematical Modeling
3	Fuzzy Set Theory	3	Stochastic Processes
Elective III		**Elective IV**	
1	Integral Equations and Calculus of Variations	1	Theory of Probability
2	Financial Mathematics	2	Tensor Analysis and Special Theory of Relativity
3	Combinatorics	3	Algebraic Topology

SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES

Sl. No.	Types of the Courses	No. of Courses	No. of Credits	Marks
1.	Core Courses	10	50	800
2.	Core Choice Courses	3	15	300
3.	Elective Courses	4	16	300
4.	Entrepreneurship/ Industry Based Course	1	5	100
5.	Project	1	5	100
6.	Non-Major Elective Courses	2	4	200
	Total	**21**	**90**	**2100**
	Value Added Courses *	2*	4*	200*

PROGRAMME OUTCOMES:

- Master Degree Programme in Mathematics will meet the present day needs of academic and Research, Institutions and Industries.
- Students may acquire depth knowledge in Algebra, Analysis, Topology, Functional Analysis, Optimization Techniques and Graph Theory which will motivate the students to go for higher studies/research in Mathematics.
- Inculcate critical thinking to carry out scientific investigation objectively without being biased with preconceived notions.
- Prepare students for pursuing research or careers in mathematical sciences and applied fields.
- Equip the student with skills to analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof.

PROGRAMME SPECIFIC OUTCOMES:

- Mastery of Fundamental Mathematical Concepts (Algebra, Analysis, Geometry)
- Will gain the ability to understand and deal with abstract concepts
- Communicate mathematical concepts effectively
- Ability to think critically and creatively
- Analyze and model real world problems based on mathematical principles
- Ability to solve problems which are modeled
- Communicate the solutions in rigorous mathematical language
- Ability to progress independently and ethically

EMPLOYABILITY OPPORTUNITIES:

After completing M.Sc. Mathematics programme, students can

- Proceed higher studies and become an academician such as professors etc.
- Be a scientific officer on ISRO, DRDO, NAL.
- Play a big role in Information and Communication Technology.
- Be a Datascience modelers.
- Be a Quantitative Risk Analyst.
- Be an interest rate trading strategist.
- Be an operational researchers.
- Become a crypto-engineer.
- Be a professional in investment banking.
- Clear any eligible competitive examination and become a state or central government employee.

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First Year | **CORE COURSE I** | **Semester: I**

ALGEBRA

Code: | **(Theory)** | **Credit: 5**

OBJECTIVES:

- To give foundation in Algebraic structures like Groups ,Rings
- To train the students in problem solving in Algebra

UNIT – I:

Set Theory – Mappings – Group – Subgroups – A counting Principle - Normal Subgroups and Quotient groups.

UNIT – II:

Homomorphism – Cayley's theorem – Permutation groups – Another counting principle – Sylow's theorems.

UNIT – III:

Homomorphisms -Ideals and quotient rings – More ideals and quotient rings – Euclidean Rings-A particular Euclidean Ring.

UNIT – IV:

Polynomial rings – Polynomials over the rational field – polynomials over commutative Rings -Inner Product spaces.

UNIT – V:

FIELDS: Extension fields – Roots of Polynomials – More about roots – The elements of Galois theory– Finite fields.

UNIT – VI CURRENT CONTOUR (For Continuous Internal Assessment Only):

Classification of finite Groups - Commutative rings, Applications of field theory to coding theory.

REFERENCES:

1. I.N. Herstein, Topics in Algebra, Second Edn, Wiley Eastern Limited.
   UNIT – I - Chapter 1: Sec 1.1, 1.2 Chapter 2: Sec 2.1 – 2.6
   UNIT – II - Chapter 2: Sec 2.7, 2.9, 2.10, 2.11, 2.12
   UNIT – III - Chapter 3: Sec 3.3, 3.4, 3.5, 3.7, 3.8.
   UNIT – IV - Chapter 3: 3.9, 3.10, 3.11 Chapter 4: 4.4
   UNIT – V - Chapter 5: Sec 5.1, 5.3, 5.5, 5.6 Chapter 7: Sec 7.1
2. David S. Dummit and Richard M. Foote, Abstract Algebra, Third Edition, Wiley Student Edition, 2015.
3. John, B. Fraleigh, A First Course in Abstract Algebra, Addison-Wesley Publishing Company.

4. Vijay, K. Khanna, and S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House Pvt Limited, 1993.
5. Joseph A. Gallian, Contemporary Abstract Algebra, Fourth Edition, Narosa publishing House, 1999.
6. http://www.math.stonybrook.edu/~irwin/algbk.pdf
7. https://www.math.usm.edu/perry/old_classes/mat423fa11/notes_25aug2011.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Gain expertise in the basic concepts of group theory with the help of numerous examples.
- Discuss in detail about permutation groups and Normal subgroups and discuss on counting tricks in algebra.
- Bring out the key steps involved in proving Sylow theorems and use Sylow's theorems to classify groups of finite order upto 120.
- Learn the fundamental concept in field theory of field extensions and would see the idea of generating new fields.
- Have clear cut idea in the notions of Galois groups, normal extensions and separable extensions and illustrate them with various examples.
- Able to understand the Fundamental theorem of Galois theory.

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First Year **CORE COURSE II** **Semester: I**

REAL ANALYSIS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To enable the students to learn the basic concepts of Real Analysis and techniques in Analysis to prepare for the advanced courses like Functional Analysis and Advanced Analysis.

UNIT – I:

The Real and Complex Number Systems: Introduction – Ordered sets – Fields–The Real Field – Extended Real Number system–The Complex Field – Euclidean Spaces. Basic topology: Finite, countable and uncountable sets – Metric Spaces – Compact sets – Perfect sets – Connected sets.

UNIT – II:

Numerical Sequences: Convergent Sequences – Sub-sequences – Cauchy Sequences – Upper and Lower Limits – Some Special Sequences – Series– Series of Non-Negative Terms. Numerical Series: The Number e – The Root and Ratio Test – Power Series – Summation by Parts – Absolute Convergence- Addition and Multiplication of Series - Rearrangements.

UNIT – III:

Continuity: Limits of Functions - Continuous Functions – Continuity and Compactness – Continuity and Connectedness – Discontinuities – Monotonic Functions – Infinite Limits and Limits at Infinity. Differentiation: The Derivative of a Real Function – Mean Value Theorems – The Continuity of Derivatives – L'Hospital's Rule – Derivatives of Higher Order – Taylor's Theorem – Differentiation of Vector Valued Functions.

UNIT – IV:

The Riemann-Stieltjes Integral: Definition and existence of the integral – Properties of the Integral – Integration and Differentiation – Integration and vector valued functions – Rectifiable curves.

UNIT – V:

Sequence and Series of Functions: Sequence of Functions – Discussion of Main Problem–Uniform Convergence and Continuity –Uniform Convergence and Integration – Uniform Convergence and Differentiation. Families of Functions: Equi continuous Families of Functions – The Stone – Weierstrass Theorem.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Generalizations to topological spaces, Calculus on Manifolds.

REFERENCES:

1. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition Tata McGraw-Hill 1985.
   UNIT – I - Chapter 1: Sec 1.1 – 1.38 & Chapter 2: Sec 2.1 – 2.47
   UNIT – II - Chapter 3: Sec 3.1 – 3.55
   UNIT – III - Chapter 4: Sec 4.1 – 4.34Chapter 5: Sec 5.1 – 5.19
   UNIT – IV - Chapter 6: Sec 6.1 – 6.27
   UNIT – V - Chapter 7: Sec 7.1 – 7.33
2. Tom. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1997.
3. R. G. Bartle, D. R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, New York, 1982.
4. Kenneth A. Ross, Elementary Analysis: The Theory of Calculus, Springer NewYork, 2004.
5. N. L.Carothers, Real Analysis, Cambridge University Press, UK, 2000.
6. S. C. Malik, Mathematical Analysis,Willey Eastern Ltd, NewDelhi, 1985.
7. K. R. Stromberg, An Introduction to Classical Real Analysis, Wadsworth, 1981.
8. H. L. Royden, Real Analysis, Third Edition, Macmillan Publishing Company, New Delhi, 1988.
9. https://s2pnd-matematika.fkip.unpatti.ac.id/wp-content/uploads/2019/03/Real-Analysis-4th-Ed-Royden.pdf
10. http://www.freebookcentre.net/maths-books-download/gotoweb.php?id=9633

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Describe fundamental properties of the real numbers that lead to the formal development of real analysis.
- Demonstrate an understanding of limits ad how that are used in sequences.
- Demonstrate an understanding of limits ad how that are used in series.
- Demonstrate an understanding of limits ad how that are used in sequences Examine and recognize the continuity of real functions.
- Demonstrate an intuitive and computational understanding of set theory, Continuity and solving application problems. This will be assessed through homework, class quizzes and tests, and a final exam.

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First Year **CORE COURSE III** **Semester: I**

ORDINARY DIFFERENTIAL EQUATIONS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To give an in-depth knowledge of differential equations and their applications.
- To study the existence, uniqueness, stability behavior of the solutions of the ODE.

UNIT – I:

The general solution of the homogeneous equation– he use of one known solution to find another – The method of variation of parameters – Power Series solutions. A review of power series– Series solutions of first order equations – Second order linear equations; Ordinary points.

UNIT – II:

Regular Singular Points – Gauss's hypergeometric equation – The Point at infinity - Legendre Polynomials – Bessel functions – Properties of Legendre Polynomials and Bessel functions.

UNIT – III:

Linear Systems of First Order Equations – Homogeneous Equations with Constant Coefficients – The Existence and Uniqueness of Solutions of Initial Value Problem for First Order Ordinary Differential Equations – The Method of Solutions of Successive Approximations and Picard's Theorem.

UNIT – IV:

Oscillation Theory and Boundary value problems – Qualitative Properties of Solutions – Sturm Comparison Theorems – Eigen values, Eigen functions and the Vibrating String.

UNIT – V:

Nonlinear equations: Autonomous Systems; the phase plane and its phenomena – Types of critical points; Stability – critical points and stability for linear systems – Stability by Liapunov's direct method – Simple critical points of nonlinear systems.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

System of ode and using Canonical forms to solve.

REFERENCES:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, TMH, New Delhi, 1984.
   UNIT – I - Chapter 3: Sections 15, 16, 19 and Chapter 5: Sections 25 to 27
   UNIT – II - Chapter 5: Sections 28 to 31 and Chapter 6: Sections 32 to 35
   UNIT – III - Chapter 7: Sections 37, 38 and Chapter 11: Sections 55, 56
   UNIT – IV - Chapter 4: Sections 22 to 24
   UNIT – V - Chapter 8: Sections 42 to 44
2. W.T. Reid, Ordinary Differential Equations, John Wiley & Sons, New York, 1971.
3. E.A. Coddingtonand N. Levinson, Theory of Ordinary Differential Equaitons, McGraw Hill Publishing Company, New York, 1955.
4. http://www.freebookcentre.net/maths-books-download/gotoweb.php?id=8714
5. https://s3.amazonaws.com/open-bookshelf-content/Open+Textbook+Library/URI/urn%3Auuid%3Ae46a68f9-3e84-4999-b9f6-18c3dfb2faca/Ordinary+Differential+Equations.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

1. Find the general solution of the first order linear homogeneous equations.
2. Understand the utility of the theory of power series which is studied in Real Analysis course through solving various second order differential equations.
3. Get introduced to the Hypergeometricfunctions which arises in connection with solutions of the second order ordinary differential equations with regular singular points.
4. Solve the problems arises in Mathematical physics using properties of special functions.
5. Understand the importance of studying well-posedness of the problem namely existence, uniqueness and continuous dependence of first order differential equations through Picard's theorem.
6. Understand the utility of the concepts from linear algebra and analysis in the study of system of first order equations.
7. Discuss the Qualitative properties of solutions of first and second order equations. Also they will be able to work on numerous problems using comparison theorem in Sturm Liouville problems.
8. Learn the nature of solutions which involves critical points and phase portrait of nonlinear equations.

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First Year **CORE CHOICE COURSE I** **Semester: I**

1) CLASSICAL DYNAMICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To give a detailed knowledge of the mechanical system of particles.
- To study the applications of Lagrange's and Hamilton's equations.

UNIT – I:

Introductory concepts: The mechanical system - Generalised Coordinates - constraints - virtual work - Energy and momentum.

UNIT – II:

Lagrange's equation: Derivation and examples - Integrals of the Motion - Small oscillations.

UNIT – III:

Special Applications of Lagrange's Equations: Rayleigh's dissipation function - impulsive motion - Gyroscopic systems - velocity dependent potentials.

UNIT – IV:

Hamilton's equations: Hamilton's principle - Hamilton's equations - Other variational principles - phase space.

UNIT – V:

Hamilton - Jacobi Theory: Hamilton's Principal Function – The Hamilton - Jacobi equation - Separability.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Introduction to relativity

REFERENCES:

1. Donald T. Greenwood, Classical Dynamics, PHI Pvt. Ltd., New Delhi-1985.
   UNIT – I - Chapter 1: Sections 1.1-1.5
   UNIT – II - Chapter 2: Sections 2.1-2.4
   UNIT – III - Chapter 3: Sections 3.1-3.4
   UNIT – IV - Chapter 4: Sections 4.1-4.4
   UNIT – V - Chapter 5: Sections 5.1-5.3
2. H. Goldstein, Classical Mechanics, (2nd Edition), Narosa Publishing House, New Delhi.
3. Narayan Chandra Rana&PromodSharad Chandra Joag, Classical Mechanics, Tata Mc Graw Hill, 1991.

4. https://www.pdfdrive.com/download.pdf?id=158582740&h=933106dae8af21f34ec9c7549706b1ed&u=cache&ext=pdf
5. https://www.pdfdrive.com/download.pdf?id=33509812&h=f116b9421b66220f909db64ed8661069&u=cache&ext=pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand the important definitions and introductory concepts like the ideas of virtualwork and d'Alembert's principle.
- Derive Lagrange's equations of motion using d'Alembert's principle.
- Understand the nature of equations of motion for holonomic and nonholonomic systems.
- Understand the idea of impulsive constraints.
- Compare dissipative systems and velocity dependent potentials.
- Understand the Hamiltonian view point of dynamics in canonical equations of motion and phase space.
- Understand the concepts of Hamilton - Jacobi theory.
- Obtain some concrete procedure for solving problems using the theory of canonical transformations.

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First Year | **CORE CHOICE COURSE I** | **Semester: I**

2) AUTOMATA THEORY

Code: | **(Theory)** | **Credit: 5**

COURSE OBJECTIVES:

- To make the students to understand the nuances of Automata and Grammar.
- To make them to understand the applications of these techniques in computer science.

UNIT – I:

Finite Automata and Regular expressions: Definitions and examples - Deterministic and Nondeterministic finite Automata - Finite Automata with - moves.

UNIT – II:

Context free grammar: Regular expressions and their relationship with automation - Grammar -Ambiguous and unambiguous grammars - Derivation trees – Chomsky Normal form.

UNIT – III:

Pushdown Automaton: Pushdown Automaton - Definition and examples - Relation with Context free languages.

UNIT – IV:

Finite Automata and lexical analysis: Role of a lexical analyzer - Minimizing the number of states of a DFA -Implementation of a lexical analyzer.

UNIT – V:

Basic parsing techniques: Parsers - Bottom up Parsers - Shift reduce - operator precedence - Top down Parsers - Recursive descent - Predictive parsers.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Applications of automata on infinite words to logic and program verification

REFERENCES:

1. John E. Hopcroft and Jeffrey D. Ullman, Introduction to Automata theory, Languages and Computations, Narosa Publishing House, Chennai, 2000.
2. A.V. Aho and Jeffrey D. Ullman, Principles of Compiler Design, Narosa Publishing House, Chennai, 2002.

UNIT – I - Chapter 2: Sections2.1-2.4 of (1)
UNIT – II - Chapter 2: Section 2.5, Chapter 4: Sections 4.1-4.3, 4.5,4.6 of (1)
UNIT – III - Chapter 5: Section 5.2, 5.3 of (1)

UNIT – IV - Chapter 3: Section 3.1-3.8 of (2)
UNIT – V - Chapter 5: Sections 5.1-5.5 of (2)

3. Harry R. Lewis and Christos H. Papadimitriou, Elements of the Theoryof Computation, Second Edition, Prentice Hall, 1997.
4. A.V. Aho, Monica S. Lam, R. Sethi, J.D. Ullman, Compilers: Principles,Techniques and Tools, Second Edition, Addison-Wesley, 2007.
5. https://www.pdfdrive.com/download.pdf?id=43053701&h=c8a1bf37c9665471f52f8dbbb722fcad&u=cache&ext=pdf
6. https://www.pdfdrive.com/download.pdf?id=165866660&h=fd2fb0e39a54f5571a50d79af60958df&u=cache&ext=epub

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Relate practical problems to languages, automata, and computability
- Demonstrate an increased level of mathematical sophistication
- Apply mathematical and formal techniques for solving problems

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First Year **ELECTIVE COURSE I** **Semester: I**

1) GRAPH THEORY

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To give a rigorous study of the basic concepts of Graph Theory.
- To study the applications of Graph Theory in other disciplines.

Note: Theorems, Propositions and results which are starred are to be omitted.

UNIT – I:

Basic Results: Basic Concepts - Subgraphs - Degrees of Vertices - Paths and Connectedness- Operations on Graphs - Directed Graphs: Basic Concepts – Tournaments.

UNIT – II:

Connectivity: Vertex Cuts and Edge Cuts - Connectivity and Edge - Connectivity, Trees: Definitions, Characterization and Simple Properties - Counting the Number of Spanning Trees - Cayley’s Formula.

UNIT – III:

Independent Sets and Matchings: Vertex Independent Sets and Vertex Coverings - Edge Independent Sets -Matchings and Factors - Eulerian Graphs - Hamiltonian Graphs.

UNIT – IV:

Graph Colourings: Vertex Colouring - Critical Graphs - Triangle - Free Graphs - Edge Colouringsof Graphs - Chromatic Polynomials.

UNIT – V:

Planarity: Planar and Nonplanar Graphs - Euler Formula and its Consequences - K5 and K3,3 are Nonplanar Graphs - Dual of a Plane Graph - The Four-Colour Theorem and the Heawood Five-Colour Theorem-Kuratowski’s Theorem.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

The Four Color Conjecture

REFERENCES:

1. R. Balakrishnan, K. Ranganathan, A Textbook of Graph Theory, Springer International Edition, New Delhi, 2008.
   UNIT I - Chapter I & II: 1.1 to 1.4, 1.7, 2.1, 2.2
   UNIT II - Chapter III & IV: 3.1, 3.2, 4.1, 4.3 to 4.4
   UNIT III - Chapter V & VI: 5.1 to 5.4, 6.1, 6.2

UNIT IV - Chapter VII: 7.1 to 7.4, 7.7
UNIT V - Chapter VIII: 8.1 to 8.6

2. J.A. Bondy, U.S.R. Murty, Graph Theory with Applications, Mac MilanPress Ltd., 1976.
3. Gary Chartrand, Linda Lesniak, Ping Zhang, Graphs and Digraph,CRC press,2010.
4. F.Harary, Graph Theory, Addison - Wesley, Reading, Mass., 1969.
5. https://www.whitman.edu/mathematics/cgt_online/cgt.pdf
6. https://www.pdfdrive.com/download.pdf?id=188461519&h=0e27445c1a90d11918eeab7108536b09&u=cache&ext=pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand and work on the fundamental concepts of graphs.
- Apply graph theory based tools in solving practical problems.
- Understand basic concepts in Trees and discuss matching problems and its applications elsewhere.
- Comprehend and work on the concepts of planarity and discuss the dual of a plane graph.

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First Year | **ELECTIVE COURSE I** | **Semester: I**

2) DISCRETE MATHEMATICS

Code: | **(Theory)** | **Credit: 4**

COURSE OBJECTIVES:

- To study the concepts like Boolean algebra, coding theory.
- To introduce the different notions grammar.

UNIT – I:

Relations and Functions: Binary relations, equivalence relations and partitions, partial order relations, inclusion and exclusion principle, Hasse diagram, Pigeon hole principle. Functions, inverse functions, compositions of functions, recursive functions.

UNIT – II:

Mathematical Logic: Logic operators, Truth tables, Theory of inference and deduction, mathematical calculus, predicate calculus, predicates and qualifiers.

UNIT – III:

Lattices: Lattices as Partially Ordered Sets. Their Properties, Lattices as algebraic Systems, Sub lattices, Direct Product and homomorphism. Some Special Lattices - Complete, Complemented and Distributive Lattices, Isomorphic Lattices.

UNIT – IV:

Boolean algebra: Various Boolean identities, the switching Algebra Example, Sub Algebras, Direct Production and Homomorphism. Boolean Forms and their Equivalence, Midterm Boolean forms, Sum of Products, Canonical Forms. Minimization of Boolean Functions.The Karnuagh Map Method.**Coding Theory:** Coding of binary information and error detection, Group codes, decoding and error correction.

UNIT – V:

Grammar and Languages: Phrase structure grammars, rewriting rules, derivation sentential forms, language generated by grammar, regular, context free and context sensitive grammar and languages.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Perron -Frobenius theorem and Google's Page rank.

REFERENCES:

1. Trembly. J.P &Manohar. P., “Discrete Mathematical Structures with Applications to Computer Science” McGraw- Hill.
2. Liu, C.L., “Elements of Discrete Mathematics”, McGraw-Hill Book co.

3. K.D Joshi, "Foundations of Discrete Mathematics", Wiley Eastern Limited.
4. Kolman, Busy & Ross, "Discrete Mathematical Structures", PHI.
5. Alan Doer: "Applied Discrete Structure for Computer Science", Galgotia Publications Pvt. Ltd.
6. Seymour Lipschutz, M. Lipson: "Discrete Mathematics", McGraw-Hill Edition.
7. Kenneth G. Roden: "Discrete Mathematics and its Applications", McGraw-Hill international editions, Mathematics Series.
8. http://discrete.openmathbooks.org/pdfs/dmoi-tablet.pdf
9. https://www.pdfdrive.com/download.pdf?id=6841453&h=4e81fe396ba8fe28e9fddc1f328c6fc3&u=cache&ext=pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand relations and functions and work with them.
- Understand functions of logic gates and use it to carry out logical operations on single or multiple binary inputs and give one binary output.
- Work with fundamental concepts and basic laws of Boolean algebra.

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First Year	ELECTIVE COURSE I 3) FUZZY SET THEORY	Semester: I
Code:	**(Theory)**	**Credit: 4**

COURSE OBJECTIVES:

- To introduce the concept of fuzzy theory and study its application in real problems
- To study the uncertainty environment through the fuzzy sets that incorporates imprecision and subjectivity into the model formulation and solution process.

UNIT – I:

From Classical Sets To Fuzzy Sets, Fuzzy Sets Verses Crisp Sets: Fuzzy sets: Basic types – Fuzzy sets: Basic Concepts –Additional Properties of α – cuts- Extension Principle for fuzzy sets.

UNIT – II:

Operations On Fuzzy Sets: Types of operations– Fuzzy complements- Fuzzy Intersections: t-Norms – Fuzzy Unions: t-Conorms - Combinations of Operations.

UNIT – III:

Fuzzy Arithmetic: Fuzzy numbers - Linguistic variables - Arithmetic operations on intervals – Arithmetic operations on Fuzzy numbers.

UNIT – IV:

Fuzzy Relations: Binary Fuzzy Relations – Binary Relations on a Single Set – Fuzzy Equivalence Relations – Fuzzy Compatibility Relations –Fuzzy Ordering Relations – Fuzzy Morphisms.

UNIT – V:

Fuzzy Decision Making: Individual decision making – Multiperson Decision Making-Ranking methods – Fuzzy Linear programming.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Bipolar fuzzy sets

REFERENCES:

1. George J. Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic Theory and Applications, Prentice Hall of India, (2005).
   UNIT I - Chapter 1 Sec1.3, 1.4, Chapter :2 Sec 2.1, 2.3
   UNIT II - Chapter 3 Sec 3.1, 3.2, 3.3, 3.4, 3.5.
   UNIT III - Chapter 4 Sec4.1,4.2, 4.3, 4.4.
   UNIT IV- Chapter 5 Sec 5.3 ,5.4, 5.5, 5.6, 5.7, 5.8.

UNIT V - Chapter 15 Sec 15.2,15.3, 15.6, 15.7
2. H.J. Zimmermann, Fuzzy Set Theory and its Applications, Allied Publishers Limited (1991).
3. M. Ganesh, Introduction to Fuzzy sets and Fuzzy logic, Prentice Hall of India, New Delhi (2006).
4. https://cours.etsmtl.ca/sys843/REFS/Books/ZimmermannFuzzySetTheory2001.pdf
5. https://www.mdpi.com/books/pdfdownload/book/4344

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Interpret fuzzy set theory and uncertainty concepts.
- Identify the similarities and differences between probability theory and fuzzy set theoryand their application conditions.
- Apply fuzzy set theory in modeling and analyzing uncertainty in a decision problem.
- Apply fuzzy control by examining simple control problem examples.

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First Year **CORE COURSE IV** **Semester: II**

COMPLEX ANALYSIS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To learn the various intrinsic concepts and the theory of Complex Analysis.
- To study the concept of Analyticity, Complex Integration and Infinite Products in depth.

UNIT – I:

Elementary Point Set Topology: Sets and Elements – Metric Spaces – Connectedness – Compactness – Continuous Functions – Topological Spaces; Conformality: Arcs and Closed Curves – Analytic Functions in Regions – Conformal Mapping – Length and Area; Linear Transformations: The Linear Group – The Cross Ratio – Symmetry.

UNIT – II:

Fundamental theorems in complex integration: Line Integrals – Rectifiable Arcs – Line Integrals as Functions of Arcs – Cauchy's Theorem for a Rectangle – Cauchy's Theorem in a Disk; Cauchy's Integral Formula: The Index of a Point with Respect to a Closed Curve – The Integral Formula – Higher Derivatives.

UNIT – III:

Local Properties of Analytic Functions - Removable Singularities - Taylor's Theorem – Integral representation of the nth term - Zeros and Poles – Algebraic order of f(z) – Essential Singularity - The Local Mapping – The Open Mapping Theorem - The Maximum Principle.

UNIT – IV:

The General Form of Cauchy's Theorem: Chains and Cycles – Simple Connectivity – Homology – The General Statement of Cauchy's Theorem – Proof of Cauchy's Theorem – Locally Exact Differentials – Multiply Connected Regions; The Calculus of Residues: The Residue Theorem – The Argument Principle – Evaluation of Definite Integrals.

UNIT – V:

Harmonic Functions: Definition and Basic Properties – The Mean-value Property – Poisson's Formula – Schwarz's Theorem – The Reflection Principle; Power series expansions-Weierstrass's Theorem – The Taylor Series – The Laurent Series.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Analytic Continuation - Global version of Cauchy's theorem

REFERENCES:

1. Lars V. Ahlfors, Complex Analysis, Third Ed. McGraw-Hill Book Company, Tokyo, 1979.
   UNIT – I - Chapter 3: 1.1-1.6, 2.1-2.4,3.1-3.3
   UNIT – II - Chapter 4: 1.1-1.5, 2.1-2.3
   UNIT – III - Chapter 4: 3.1, 3.2, 3.3,3.4
   UNIT – IV - Chapter 4: 4.1-4.7, 5.1-5.3
   UNIT – V - Chapter 4: 6.1-6.5 and Chapter 5: 1.1-1.3
2. Serge Lang, Complex Analysis, Addison Wesley, 1977.
3. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, NewDelhi, 1997.
4. Karunakaran, Complex Analysis, Alpha Science international Ltd,Second edition, 2005.
5. https://s2pnd-matematika.fkip.unpatti.ac.id/wp-content/uploads/2019/03/John-M.-Howie-Complex-Analysis-Springer-Undergraduate-Mathematics-Series-Springer-2007.pdf
6. https://mccuan.math.gatech.edu/courses/6321/lars-ahlfors-complex-analysis-third-edition-mcgraw-hill-science_engineering_math-1979.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand the complex number system from geometric view point. Will gain mastery in arguments on C* and logarithms.
- Get expertise in the concept of convergence of sequences and series of complex numbers, continuity and differentiability of function on complex numbers. Also the students will be able to thoroughly understand and know the importance of power series in complex analysis.
- Workout the path integrals on the complex plane.
- Understand the central theme of Cauchy theory, viz., existence of local primitives and local power series expansion.
- Get acquainted with various techniques of proving fundamental theorem of algebra, open mapping theorem, maximum modulus theorem and Liouville's theorem.
- Classify singularities, compute poles and residues and understand the Laurent series expansion.
- Appreciate and work on the topology of extended complex plane.

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First Year	CORE COURSE V LINEAR ALGEBRA (Theory)	Semester: II
Code:		Credit: 5

COURSE OBJECTIVES:

- To give the students a thorough knowledge of the various aspects of Linear Algebra
- To train the students in problem-solving as a preparatory for competitive exam.

UNIT – I:

Matrices: Systems of linear Equations - Matrices and Elementary Row operations -Row-reduced echelon Matrices - Matrix Multiplication - Invertible Matrices-Bases and Dimension. (Only revision of Vector spaces and subspaces).

UNIT – II:

Linear transformations: The algebra of linear transformations - Isomorphism of Vector Spaces -Representations of Linear Transformations by Matrices - Linear Functionals - The Double Dual - The Transpose of a Linear Transformation.

UNIT – III:

Algebra of polynomials: The algebra of polynomials - Lagrange Interpolation - Polynomial Ideals -The prime factorization of a polynomial - Commutative rings – Determinant functions.

UNIT – IV:

Determinants: Permutations and the uniqueness of determinants - Classical Adjoint of a (square) matrix - Inverse of an invertible matrix using determinants - Characteristic values - Annihilating polynomials.

UNIT – V:

Diagonalization: Invariant subspaces - Simultaneous triangulation and simultaneous Diagonalization Direct-sum Decompositions - Invariant Direct sums – Primary Decomposition theorem.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Introduction to Module theory

REFERENCES:

1. Kenneth Hoffman and Ray Alden Kunze, Linear Algebra, Second Edition, Prentice Hall of India Private Limited, New Delhi, 1975.
   UNIT – I - Chapter 1 & 2 1.2-1.6 and 2.3
   UNIT – II - Chapter 3
   UNIT – III - Chapter 4 & 5 4.1 - 4.5 and 5.1 - 5.2
   UNIT – IV - Chapter 5 & 6 5.3, 5.4 and 6.1 - 6.3

UNIT – V - Chapter 6 6.4 - 6.8
2. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice-Hall of India Ltd, 2004.
3. V. Krishnamurthy, V.P. Mainra, J.L. Arora, Introduction to Linear Algebra,East West Press Ltd, 1985.
4. A.R. Rao, P. Bhimashankaram, Linear Algebra, Second Edition, Tata McGraw Hill, 2000.
5. Edgar G.Goodaire,Linear Algebra-Pure & Applied World Scientific,Cambridge University Press India Ltd, 2014.
6. https://joshua.smcvt.edu/linearalgebra/book.pdf
7. https://resources.saylor.org/wwwresources/archived/site/wp-content/uploads/2012/02/Linear-Algebra-Kuttler-1-30-11-OTC.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Realise that the subject evolves as a generalization of solving a system of linear equations.
- Discuss in detail the basic concepts of Linear dependence, basis and dimension of a vector space. The students will be able to demonstrate how the geometric ideas turn into rigorous proofs.
- Master the dimension formula and rank and nullity theorem which are often exploited.
- Capture the idea of producing lot of structure preserving maps (Linear transformations). Further the study of algebras of linear maps would be accomplished.
- Having got trained in numerous examples the student realizes the isomorphic theory of linear transformations and matrices.
- Learn the theory of determinants and put them in practice.
- Understand that the central theme of structure theory of linear maps is to decompose the given vector space as a direct sum of generalized the Eigen spaces using the given map on it.
- Understand that linear Algebra plays a fundamental role in many areas of mathematics including Algebra, Geometry, Functional analysis and which finds widest application in Physics, Chemistry and elsewhere.

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First Year **CORE CHOICE COURSE II** **Semester: II**

1) PARTIAL DIFFERENTIAL EQUATIONS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To give an in-depth knowledge of solving partial differential equations and apply them in scientific and engineering problems.
- To study the other aspects of PDE.

UNIT – I:

Partial differential equations- origins of first order Partial differential equations- Cauchy's problem for first order equations- Linear equations of the first order- Integral surfaces Passing through a Given curve- surfaces Orthogonal to a given system of surfaces -Nonlinear Partial differential equations of the first order.

UNIT – II:

Cauchy's method of characteristics- compatible systems of first order equations- Charpits method- Special types of first order equations- Solutions satisfying given conditions- Jacobi's method.

UNIT – III:

Partial differential equations of the second order: The origin of second order equations –second order equations in Physics – Higher order equations in Physics - Linear partial differential equations with constant co-efficient- Equations with variable coefficients-Characteristic curves of second order equations.

UNIT – IV:

Characteristics of equations in three variables- The solution of Linear Hyperbolic equations-Separation of variables.The method of Integral Transforms – Non Linear equations of the second order.

UNIT – V:

Laplace equation: Elementary solutions of Laplace's equations-Families of equipotential Surfaces- Boundary value problems-Separation of variables – Problems with Axial Symmetry.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Greens function - Theory of distributions.

REFERENCES:

1. Ian N. Sneddon,Elements of Partial differential equations, Dover Publication – INC, New York, 2006.
   UNIT – I - Chapter II Sections 1 to 7

UNIT – II - Chapter II Sections 8 to 13
UNIT – III - Chapter III Sections 1 to 6
UNIT – IV - Chapter III Sections 7 to 11
UNIT – V - Chapter IV Sections 2 to 6

2. M.D. Raisinghania, Advanced Differential Equations, S. Chand and company Ltd., New Delhi,2001.
3. E.T. Copson, Partial Differential Equations, Cambridge University Press.
4. https://s2pnd-matematika.fkip.unpatti.ac.id/wp-content/uploads/2019/03/Walter-A-Strauss-Partial-differential-equations-_-an-introduction-Wiley-2009.pdf
5. http://web.math.ucsb.edu/~moore/pde.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Classify first order partial differential equations and their solutions.
- Solve first order equations and nonlinear partial differential equations using various methods.
- Use the method of characteristics to solve first order partial differential equations.
- Identify and solve the three main classes of second order equations, elliptic, parabolic and hyperbolic.
- Solve one dimensional wave equations using method of separation of variables.
- Classify the boundary value problems and analyse its solutions.
- Solve Heat conduction problem using Fourier series and cosines.
- Illustrate the use of PDE in problems from Engineering and Biological Sciences.

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First Year **CORE CHOICE COURSE II** **Semester: II**

2) NON LINEAR DIFFERENTIAL EQUATIONS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To study Non linear Differential Equation and its properties.
- To study oscillation and stability properties of the solutions.

UNIT – I:

First order systems in two variables and linearization: The general phase plane-some population models – Linear approximation at equilibrium points – Linear systems in matrix form.

UNIT – II:

Averaging Methods: An energy balance method for limit cycles – Amplitude and frequency estimates – slowly varying amplitudes – nearly periodic solutions - periodic solutions: harmony balance – Equivalent linear equation by harmonic balance – Accuracy of a period estimate.

UNIT – III:

Perturbation Methods: Outline of the direct method – Forced Oscillations far from resonance - Forced Oscillations near resonance with Weak excitation – Amplitude equation for undamped pendulum – Amplitude Perturbation for the pendulum equation – Lindstedt's Method – Forced oscillation of a self – excited equation – The Perturbation Method and Fourier series.

UNIT – IV:

Linear Systems: Time Varying Systems – Constant coefficient System – Periodic Coefficients – Floquet Theory – Wronskian.

UNIT – V:

Stability: Poincare stability – solutions, paths and norms – Liapunov stability Stability of linear systems – Comparison theorem for the zero solutions of nearly – linear systems.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Solving non-linear equations using MATLAB

REFERENCES:

1. D.W. Jordan & P. Smith, Nonlinear Ordinary Differential Equations, Clarendon Press, Oxford, 1977.

2. Differential Equations by G.F.Simmons, Tata McGraw Hill, NewDelhi (1979).
3. Ordinary Differential Equations and Stability Theory ByD.A.Sanchez, Freeman (1968).
4. Notes on Nonlinear Systems by J.K.Aggarwal, Van Nostrand, 1972.
5. http://www.freebookcentre.net/maths-books-download/gotoweb.php?id=8715
6. http://mdudde.net/pdf/study_material_DDE/M.Sc.MAthematics/DIFFERENTIAL%20EQUATIONS.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Find linear approximation at equilibrium points
- Solve simple non linear differential equation using averaging methods.
- Solve some non linear differential equation using perturbation methods.

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First Year | **ELECTIVE COURSE II** | **Semester: II**

1) OPTIMIZATION TECHNIQUES

Code: | **(Theory)** | **Credit: 4**

COURSE OBJECTIVES:

- To provide insights into structures and processors that operations research can offer and the enormous practical utility of its various techniques.
- To explain the concepts and simultaneously to develop an understanding of problem solving methods based upon model formulation, solution procedures and analysis.

UNIT – I:

Linear Programming Problem – Pure and Mixed Integer Programming Problems – Gromory's All I.P.P. Method – Construction of Gomory's Constraints - Fractional Cut Method-All Integer LPP – Fractional Cut Method-Mixed Integer LPP – Branch and Bound Method – Applications of Integer Programming.

UNIT – II:

Dynamic Programming – The Recursive Equation Approach – Characteristics of Dynamic Programming – Dynamic Programming Algorithm – Solution of Discrete DPP – Applications – Solution of LPP by Dynamic Programming.

UNIT – III:

Goal Programming – Categorisation of Goal Programming – Formulation of Linear Goal Programming Problem – Graphical Goal Attainment Method – Simplex Method for Goal Programming Problem.

UNIT – IV:

Non-Linear Programming - Formulation - constrained optimization - with equalingconstraints, with in-equaling constraints - saddle point problems.

UNIT – V:

Non-Linear Programming problems Methods - Graphical sign - Kuhn-Tucker conditions with non- negative constrains - quadratic programming - Wolfe's modified simplex method - Beale's method - separable convex programming - separable programming Algorithm.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Solving problems using PYTHON Programming

REFERENCES:

1. KantiSwarup, P.K. Gupta, Man Mohan, Operations Research, Sultan Chand & sons, New Delhi, 2019.

UNIT – I Chapter 7
UNIT – II Chapter 13
UNIT – III Chapter 8
UNIT – IV Chapter 27
UNIT – V Chapter 28

2. Hamdy A. Taha, Operations Research (10th Edn.), McGraw Hill Publications, New Delhi.2019.
3. Bazaara, Jarvis and Sherali, Linear Programming and Network Flows, 4th ed., John Wiley, 2010
4. O.L. Mangasarian, Non Linear Programming, McGraw Hill, New York, 1994.
5. Mokther S. Bazaraa and C.M. Shetty, Non Linear Programming, Theory and Algorithms, 3rd edn, Willy, New York, 2013.
6. Prem Kumar Gupta and D.S. Hira, Operations Research: An Introduction, S. Chand and Co., Ltd. New Delhi, 2014.
7. S.S. Rao, Optimization Theory and Applications, 4th edn, Wiley, 2009.
8. G. Hadley, Linear Programming, Narosa Publishing House, 2002
9. http://www.ru.ac.bd/stat/wp-content/uploads/sites/25/2019/03/405_01_Srinivasan_Operations-Research_-Principles-and-Applications-Prentice-Hall-of-India-2010.pdf
10. https://www.bbau.ac.in/dept/UIET/EME-601%20Operation%20Research.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

1. Do mathematical formulation of a real life problem into a linear programming problem.
2. Solve linear programming problem using graphical method and simplex method.
3. Understand Integer programming problem.
4. Find solutions to linear programming problem by dynamic programming.
5. Understand the concepts of nonlinear programming problems.
6. Solve nonlinear programming problems using Wolfe's method and Beale's method.

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First Year | **ELECTIVE COURSE II** | **Semester: II**

2) MATHEMATICAL MODELING

Code: | **(Theory)** | **Credit: 4**

COURSE OBJECTIVES:

- To study the different mathematical models in ODE and Difference equations.
- To study graph theoretical models.

UNIT – I:

Mathematical Modelling through Ordinary Differential Equations of First order: Linear Growth and Decay Models – Non-Linear Growth and Decay Models – Compartment Models – Dynamics problems – Geometrical problems.

UNIT – II:

Mathematical Modelling through Systems of Ordinary Differential Equations of First Order: Population Dynamics – Epidemics – Compartment Models – Economics – Medicine, Arms Race, Battles and International Trade – Dynamics.

UNIT – III:

Mathematical Modelling through Ordinary Differential Equations of Second Order: Planetary Motions – Circular Motion and Motion of Satellites – Mathematical Modelling through Linear Differential Equations of Second Order – Miscellaneous Mathematical Models.

UNIT – IV:

Mathematical Modelling through Difference Equations: Simple Models – Basic Theory of Linear Difference Equations with Constant Coefficients – Economics and Finance – Population Dynamics and Genetics – Probability Theory.

UNIT – V:

Mathematical Modelling through Graphs: Solutions that can be Modelled through Graphs – Mathematical Modelling in Terms of Directed Graphs, Signed Graphs, Weighted Digraphs and Unoriented Graphs.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Mathematical Modelling through mathematical programming, maximum principle and maximum entropy principle.

REFERENCES:

1. J.N. Kapur, Mathematical Modelling, Wiley Eastern Limited, New Delhi, 1988.
   UNIT I - Chapter 2
   UNIT II - Chapter 3
   UNIT III - Chapter 4

UNIT IV - Chapter 5 except 5.6
UNIT V - Chapter 7

2. J. N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East – West Press Pvt Limited, New Delhi, 19.
3. http://mtm.ufsc.br/~daniel/matap/IntMatMod.pdf
4. https://repository.ung.ac.id/get/kms/16993/Referensi-Mata-Kuliah-An-Introduction-to-Mathematical-Modelling.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

1. Understand the concept of a mathematical model and explain the series of steps involved in mathematical modelling.
2. Classify different classes of mathematical models.
3. Discuss features of a good model and the benefits of using a mathematical model.
4. Identify some simple real-life problems that can be solved using mathematical models.
5. Convert the physical problems as differential equations through mathematical modelling.
6. Use the ideas of directed graphs, weighted digraphs and unoriented graphs for modelling real life problems.
7. Model the problems in economics and finance, population dynamics and genetics.

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First Year	**ELECTIVE COURSE II**	**Semester: II**
	3) STOCHASTIC PROCESSES	
Code:	**(Theory)**	**Credit: 4**

COURSE OBJECTIVES:

- Acquire the knowledge about the concept of Markov Chain and Queuing system.
- Understand the methods of birth and death queues with finite and infinite capacity.
- Develop the ability of Standard Brownian Motion

UNIT – I:

Stochastic Processes: Some notions – Specification of Stochastic processes – Stationary processes – Markov Chains – Definitions and examples – Higher Transition probabilities – Generalization of independent Bernoulli trails.

UNIT – II:

Markov chains: Classification of states and chains – determination of Higher transition probabilities – stability of a Markov system – Reducible chains – Markov chains with continuous state space.

UNIT – III:

Markov processes with Discrete state space: Poisson processes and their extensions – Poisson process and related distribution – Generalization of Poisson process- Birth and Death process – Markov processes with discrete state space (continuous time Markov Chains).

UNIT – IV:

Renewal processes and theory: Renewal process – Renewal processes in continuous time – Renewal equation – stopping time – Wald's equation – Renewal theorems.

UNIT – V:

Branching Processes: Introduction – Properties of generating functions of Branching process – Probability of extinction – Distribution of the total number of progeny – Conditional Limit Laws due to Kolmogrov and due to Yaglom – Classical Galton-Watson Process - Bellman-Harris Process

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Stochastic integration and functional limit theorems.

REFERENCES:

1. J. Medhi, Stochastic Processes, New age International Publishers, New Delhi– Second edition.
   UNIT I Chapter 2 Sec 2.1-2.3, Chapter III Sec 3.1-3.3
   UNIT II Chapter 3 Sec 3.4-3.6, 3.8, 3.9,3.11
   UNIT III Chapter 4 Sec 4.1-4.5
   UNIT IV Chapter 6 Sec 6.1-6.5
   UNIT V Chapter 9 Sec 9.1-9.8
2. Samuel Karlin, Howard M. Taylor, A first course in stochastic processes, Academic press, Second Edition, 1975.
3. Narayan Bhat, Elements of Applied Stochastic Processes, John Wiley, 1972.
4. S.K. Srinivasan and K. Mehata, Stochastic Processes, Tata McGraw Hill, 1976.
5. N.V. Prabhu, Stochastic Processes, Macmillan (NY).
6. Robert G. Gallager, Stochastic Processes: Theory for Applications, Cambridge University Press, 2013.
7. http://home.ustc.edu.cn/~alex2014/SPpdf/Stochastic%20Processes%20SM.pdf
8. https://www.pdfdrive.com/download.pdf?id=187079740&h=9e25b152bf6e3cd7ad9c4e54c836b4fc&u=cache&ext=pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Acquire adequate knowledge about Continuous Time Markov chain and Queuing system.
- Gain understanding on the Renewal process, Cumulative process and Semi-Markov process.
- Apply different methods to solve birth and death queues.
- Examine the computations of renewal process and theory.
- Conclude the idea of Branching process.

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First Year **NON MAJOR ELECTIVE COURSE I** **Semester: II**

STATISTICS

Code: **(Theory)** **Credit: 2**

COURSE OBJECTIVES:

- To introduce the concepts involved in basic statistics and learn them with plenty of demonstrating examples.
- To emphasize the correct statistical tools required to analyze and understand the results based on them.

UNIT – I:

Collection, classification and tabulation of data, graphical and diagrammatic representation - Bar diagrams, Pie diagram, Histogram, Frequency polygon, frequency curve and Ogive.

UNIT – II:

Measures of central tendency - Mean, Median and Mode – Geometric Mean – Harmonic Mean – Selection of an average – Partition Values.

UNIT – III:

Measures of dispersion - Range, Quartile deviation, Mean deviation about an average, Standard deviation and co-efficient of variation for individual, discrete and continuous type data.

UNIT – IV:

Correlation - Different types of correlation - Positive, Negative, Simple, Partial Multiple, Linear and non-Linear correlation.Methods of correlation – Karl Pearson's Spearman's correlations and Concurrent deviation.

UNIT – V:

Regression types and method of analysis, Regression line, Regression equations, Deviation taken from arithmetic mean of X and Y, Deviation taken from assumed mean, Partial and multiple regression coefficients - Applications

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Usage of package R, SPSS

REFERENCES:

1. Gupta S.C. and Kapoor V.K., Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 1994.
2. Freund J.E.(2001); Mathematical Statistics, Prentice Hall of India.
3. Goon, A.M., Gupta M.K., Dos Gupta, B, (1991), Fundamentals of Statistics, Vol. I, World Press, Calcutta.

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Collect, classify and tabulate a given data and study graphical and diagrammatic representations through Bar diagrams, Pie diagram, Histogram, Frequency polygon
- Understand measures of central tendency, viz., Mean, Median and Mode in series of individual observations.
- Workout simple problems in discrete and continuous series.
- Analyze measures of dispersion namely range, quartile deviation, Mean deviation about mean, standard deviation and co-efficient of variation for individual, discrete and continuous type data.
- Distinguish different types of correlation
- Calculate Karl Pearson's correlation coefficient for a lot of problems
- Thoroughly understand and analyze the given problems with the standard regression types.
- Compute partial and multiple regression coefficient for a plenty of problems.

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First Year **VALUE ADDED COURSE I** **Semester: II**

1) INTRODUCTION TO LATEX

Code: **(Theory)** **Credit: *2**

COURSE OBJECTIVES:

- To make the students learn the art of typing mathematics text on their own.
- To inculcate professional training required to become a scholar in mathematics.

UNIT – I:

Basic Structure of Latex 2e - Input file structure - Layout -Editors - Forward Search- Inverse Search - Compiling - Conversion to various formats.

UNIT – II:

Typesetting simple documents - sectioning - Titles- page layout -listing – enumerating - quote - letter formats.

UNIT – III:

Using package amsmath typing equations labeling and referring.

UNIT – IV:

Figure inclusion - Table inclusion.

UNIT – V:

Bibliography - Index typing - Beamer presentation Styles.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Type a mathematical article using various journal style files

REFERENCES:

1. Leslie Lamport. LATEX: A Document Preparation System, Addison-Wesley, Reading, Massachusetts, second edition, 1994.
2. Tobias Oetiker, Hubert Partl, Irene Hyna and Elisabeth Schlegl., The (Not So) Short Introduction to LATEX2e, Samurai Media Limited (or available online at http://mirrors.ctan.org/info/lshort/english/lshort.pdf)
3. LATEX Tutorials - A Primer, Indian TeX Users Group, available online at https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf
4. H. J. Greenberg. A Simplified introduction to LATEX, available online at https://www.ctan.org/tex-archive/info/simplified-latex/
5. Using Kile - KDE Documentation, https://docs.kde.org/trunk4/en/extragear_office/kile/quick-using.html
6. Amsmath and geometry package available in Ctan.org.

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Type their own mathematical article/notes/book/journal paper/project work.
- Meticulously prepare their own mathematical notes.
- Understand basic structure of Latex 2e and conversions of them to various formats.
- Typeset and compile documents with titles, sectioning and enumeration etc.
- Use various style files and in particular amsmath, amsfonts, amsthm.
- Understand how to align math equations, matrices etc.
- Include the figures in various formats into their latex document and compile it successfully.
- Utilize bibtex feature of including bibliographies and indexes.

*****

First Year | **VALUE ADDED COURSE I** | **Semester: II**

2) INTRODUCTION TO MATLAB

Code: | **(Theory)** | **Credit: *2**

COURSE OBJECTIVES:

- To learn features of MATLAB as a programming tool.
- To promote new teaching model that will help to develop programming skills and technique to solve mathematical problems.
- To understand MATLAB graphic feature and its applications.
- To use MATLAB as a simulation tool.

UNIT – I:

Starting with MATLAB, MATLAB windows – Working in command window - Arithmetic operations with scalars – Display Formats - Elementary math built-in functions – Defining scalar variables - Useful commands for managing variables - Script files.

UNIT – II:

Creating Arrays – Variables - Transpose Operator - Array addressing - Adding elements to existing variables - Deleting elements - Built-in functions for handling arrays - strings and strings as variables.

UNIT – III:

Mathematical Operations with Arrays: Addition and Subtraction – Multiplication – Division - Element-by-element operations - Built-in math functions - Built-in functions for analysing arrays - Generation of random numbers.

UNIT – IV:

MATLAB workspace and the workspace window – Script file – Output commands – save and load commands – Importing and exporting commands.

UNIT – V:

plot command – fplot command - Plotting multiple graphs in the same plot – Formatting a plot – Plots with Logarithmic axes – Plots with error bars – Plots with special graphics.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Programming in MATLAB

REFERENCES:

1. Amos Gilat, MATLAB An Introduction with Applications, John Wiley & Sons, 2011.

2. Brian R. Hunt, Ronald L. Lipsman, Jonathan M. Rosenberg, A Guide to MATLAB - for Beginners and Experienced Users, 2nd Edition, Cambridge University Press, 2006.
3. Stephen J. Chapman, Essentials of MATLAB Programming, Cengage Learning, 2009.

COURSE OUTCOMES:

At the end of the course, students will be able to:

1. Understand the main features of the MATLAB development environment.
2. Use the MATLAB GUI effectively.
3. Design simple algorithms to solve problems.
4. Write simple programs in MATLAB to solve scientific and mathematical problems.

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Second Year | **CORE COURSE VI** | **Semester: III**

TOPOLOGY

Code: | **(Theory)** | **Credit: 5**

COURSE OBJECTIVES:

- To stimulate the analytical mind of the students
- Enable them to acquire sufficient knowledge and skill in the subject that will make them competent in various areas of Mathematics.

UNIT – I:

Metric Spaces: The Definition and some Examples – Open sets – Closed sets – Convergence, Completeness and Baire's theorem, Continuous mappings – Spaces of continuous functions – Euclidean and Unitary Spaces.

UNIT – II:

Topological Spaces: The Definition and some Examples – elementary concepts – open bases and open sub bases – weak topologies – The function algebra $C\ (X, R)$ and $C\ (X, C)$.

UNIT – III:

Compactness: Compact spaces – Product of spaces – Tychnoff's theorem and locally compact spaces – Compactness for Metric spaces – Ascoli's theorem.

UNIT – IV:

Separation:T_1-spaces and Hausdorff spaces – Completely regular spaces and normal spaces - The Urysohn lemma and Tietze Extension Theorem - The Urysohn imbedding theorem – The Stone-Cechcompactification.

UNIT – V:

Connectedness and Approximation: Connected spaces – The components of a space – Totally disconnected spaces - Local connected spaces – The Weierstrass approximation theorem – The Stone-Weierstrass theorem.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Elementary concepts from Algebraic topology.

REFERENCES:

1. George F. Simmons, "Introduction to Topology and Modern Analysis", McGraw Hill Book Company 1963.

   UNIT I Chapter 2: Page: 9-15
   UNIT II Chapter 3: Page: 16-20
   UNIT III Chapter 4: Page: 21-25

UNIT IV Chapter 5: Page: 26-30
UNIT V Chapter 6,7: Page: 31-36

2. James. R. Munkres, "Topology", second Edition, Prentice Hall of India Pvt., Ltd., New Delhi 2005
3. J. Dugundji, "Topology" Prentice hall of India, New Delhi 1975.
4. J. L. Kelly, "General topology", Van Nostrand Reinhold Co., New York.
5. M. G. Murdeswar "General Topology", Academic press, 1964
6. K. D. Joshi "Introduction to General Topology", Addison-Wesley, 1994.
7. S. Kumaresan, "Topology of Metric Spaces" Alpha Science International Ltd. Harrow, U.K.
8. https://ocw.mit.edu/courses/18-901-introduction-to-topology-fall-2004/pages/lecture-notes/
9. https://www.topologywithouttears.net/topbook.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

1. Study and Understand the concepts of metric spaces, topological spaces
2. Understand the concepts of open bases and open sub bases
3. Understand the concepts of Compactness, connectedness and separation axioms
4. Provide patience to grapple with life outside the campus.

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Second Year **CORE COURSE VII** **Semester: III**

MEASURE THEORY AND INTEGRATION

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- This course will enable the students to Study financial mathematics through various models and various aspects of financial mathematics

UNIT – I:

Measure on Real line: Lebesgue outer measure - Measurable sets - Regularity - Measurable function - Borel and Lebesgue measurability.

UNIT – II:

Integration of non-negative functions: The General integral - Integration of series - Riemann and Lebesgue integrals.

UNIT – III:

Abstract Measure spaces: Measures and outer measures - Completion of measures - Measure spaces - Integration with respect to a measure.

UNIT – IV:

Convergence in Measure: Almost uniform convergence- Signed Measures and Halin Decomposition –The Jordan Decomposition – Measurability in a Product space – The product Measure and Fubini's Theorem.

UNIT – V:

The Classical Banach spaces: LP spaces – Minkowski and Holder's inequality – Completeness – Approximation in LP spaces.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Riesz- Markov Kakutani Theorem.

REFERENCES:

1. G.De Barra, Measure Theory and Integration, New age international (p) Limited.
2. H. L. Royden, Real Analysis, 3rd Edition, PHI Ltd.

UNIT – I Chapter II: Sec 2.1 to 2.5 of (1)
UNIT – II Chapter III: Sec 3.1 to 3.4 of (1)
UNIT – III Chapter V: Sec 5.1 to 5.6 of (1)
UNIT – IV Chapter VII: Sec 7.1, 7.2 Chapter VIII: Sec 8.1, 8.2
Chapter X: Sec 10.1,10.2 of (1)
UNIT – V Chapter VI: Sec 6.1 to 6.4 of (2)

3. M.E. Munroe, Measure and Integration, by Addison - Wesley Publishing Company, Second Edition, 1971.
4. P.K. Jain, V.P. Gupta, Lebesgue Measure and Integration, New Age International Pvt Limited Publishers, New Delhi, 1986, Reprint 2000.
5. Richard L. Wheeden and AntoniZygmund, Measure and Integral: An Introduction to Real Analysis, Marcel Dekker Inc. 1977.
6. Inder, K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, New Delhi, 1997.
7. https://www.pdfdrive.com/download.pdf?id=161198423&h=e1440b6a787714e507bfa8eeedb5b4d4&u=cache&ext=pdf
8. https://www.pdfdrive.com/download.pdf?id=183696899&h=fcc838426bc7fc49a384dd10730fe715&u=cache&ext=pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Learn the basic concepts of measure and integration.
- Comprehend the differences between different types of convergences.
- Understand the concepts of Classical Banach Spaces
- Learn completeness and approximation in L_p-spaces.
- An overview of the central results of the theory of Lebesgue integration.

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Second Year **CORE CHOICE COURSE III** **Semester: III**

1) ADVANCED NUMERICAL ANALYSIS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To know the theory behind various numerical methods.
- To apply these methods to solve mathematical problems.

UNIT – I:

Transcendental and polynomial equations: Rate of convergence – Secant Method, Regula Falsi Method, Newton Raphson Method, Muller Method and Chebyshev Method. Polynomial equations: Descartes' Rule of Signs - Iterative Methods: Birge-Vieta method, Bairstow's method Direct Method: Graeffe's root squaring method.

UNIT – II:

System of Linear Algebraic equations and Eigen Value Problems: Error Analysis of Direct methods – Operational count of Gauss elimination, Vector norm, Matrix norm, Error Estimate. Iteration methods - Jacobi iteration method, Gauss Seidel Iteration method, Successive Over Relaxation method - Convergence analysis of iterative methods, Optimal Relaxation parameter for the SOR method. Finding eigen values and eigen vectors – Jacobi method for symmetric matrices and Power methods only.

UNIT – III:

Interpolation and Approximation: Hermite Interpolations, Piecewise and Spline Interpolation – piecewise linear interpolation, piecewise quadratic interpolation, piecewise cubic interpolation, spline interpolation-cubic Spline interpolation. Bivariate Interpolation- Lagrange Bivariate interpolation. Least square approximation.

UNIT – IV:

Differentiation and Integration: Numerical Differentiation – Optimum choice of Step length – Extrapolation methods – Partial Differentiation. Numerical Integration: Methods based on undetermined coefficients - Gauss Legendre Integration method and Lobatto Integration Methods only.

UNIT – V:

Ordinary differential equations – Singlestep Methods: Local truncation error or Discretization Error, Order of a method, Taylor Series method, Runge-Kutta methods: Explicit Runge–Kutta methods– Minimization of Local Truncation Error, System of Equations, Implicit Runge-Kutta methods. Stability analysis of single step methods (RK methods only).

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Methods for partial differential equations.

REFERENCES:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International (p) Limited Publishers, New Delhi, Sixth Edition 2012.
   UNIT – I Chapter 2: Sec 2.5 (Pages 41-52), 2.9 (Pages 83-99)
   UNIT – II Chapter 3: Sec 3.3(Pages 134-140), 3.4(Pages 146-164), 3.5(Pages 170-173), 3.7 (Pages 179-185) and 3.11 (Pages 196-198)
   UNIT – III Chapter 4: Sec 4.5 - 4.7 & 4.9 (Pages 284-290)
   UNIT – IV Chapter 5: 5.2 - 5.5(Pages 320-345) and 5.8(pages 361 – 365 and 380-386)
   UNIT – V Chapter 6: Sec 6.4(Pages 434-459) and 6.5(Pages 468-475)
2. Kendall E. Atkinson, An Introduction to Numerical Analysis, II Edn., John Wiley & Sons, 1988.
3. M.K. Jain, Numerical Solution of Differential Equations, II Edn., New Age International Pvt Ltd., 1983.
4. Samuel. D. Conte, Carl. De Boor, Elementary Numerical Analysis, McGraw-Hill International Edn., 1983.
5. http://www.freebookcentre.net/maths-books-download/gotoweb.php?id=7917
6. https://www.pdfdrive.com/download.pdf?id=160298524&h=feb69f6474f6b0343459cf47784ec248&u=cache&ext=pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Solve algebraic and transcendental equations using various iterative methods and study the rate of convergence of those problems.
- Solve System of Linear Algebraic equations using direct methods and indirect methods.
- Solve eigen value problems and study the error analysis.
- Solve algebraic equations and differential equations using the techniques of interpolation like Lagrange Interpolation, Hermite Interpolation etc.
- Perform curve fitting using least square approximation.
- Find the numerical value of the derivative of various functions using Euler method and Runge-Kutta method.
- Calculate the numerical value of a definite integral using methods like quadrature rules in numerical integration.
- Identify the suitable numerical method and perform error analysis.

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Second Year **CORE CHOICE COURSE III** **Semester: III**

2) ALGEBRAIC NUMBER THEORY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To expose the students to the charm, niceties and nuances in the world of numbers.
- To highlight some of the Applications of the Theory of Numbers.

UNIT – I:

Introduction – Divisibility – Primes – The Binomial Theorem – Congruences – Euler's totient - Fermat's, Euler's and Wilson's Theorems – Solutions of congruences – The Chinese Remainder theorem.

UNIT – II:

Techniques of numerical calculations – Public key cryptography – Prime power Moduli – Primitive roots and Power Residues –Congruences of degree two.

UNIT – III:

Number theory from an Algebraic Viewpoint – Groups, rings and fields – Quadratic Residues- The Legendre symbol (a/r) where r is an odd prime – Quadratic Reciprocity – The Jacobi Symbol (P/q) where q is an odd positive integer.

UNIT – IV:

Binary Quadratic Forms – Equivalence and Reduction of Binary Quadratic Forms – Sums of three squares – Positive Definite Binary Quadratic forms – Greatest integer Function – Arithmetic Functions – The Mobius Inversion Formula – Recurrence Functions – Combinatorial number theory.

UNIT – V:

Diophantine Equations – The equation $ax + by = c$ – Simultaneous Linear Diophantine Equations – Pythagorean Triangles – Assorted examples.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Prime Number Theorem and its applications.

REFERENCES:

1. Ivan Niven, Herbert S, Zuckerman and Hugh L, Montgomery, An Introduction to the Theory of Numbers, Fifth edn., John Wiley & Sons Inc, 2004.
   UNIT I Chapter 1 and Chapter 2: Sec 2.1 to 2.3
   UNIT II Chapter 2: Sec 2.4 to 2.9
   UNIT III Chapter 2: Sec 2.10, 2.11 Chapter 3: Sec 3.1 to 3.3

UNIT IV Chapter 3: Sec 3.4 to 3.7 and Chapter 4
UNIT V Chapter 5: Sec 5.1 to 5.4.

2. Elementary Number Theory, David M. Burton W.M.C. Brown Publishers, Dubuque, Lawa, 1989.
3. Number Theory, George Andrews, Courier Dover Publications,1994.
4. Fundamentals of Number Theory, William J. Leveque Addison-Wesley Publishing Company, Phillipines, 1977.
5. http://www.math.toronto.edu/~ila/Neukirch_Algebraic_number_theory.pdf
6. https://www.pdfdrive.com/download.pdf?id=188938191&h=4d0f9c871d3eb049e961899e1123111b&u=cache&ext=pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand and work numerous problems on concepts of divisibility and primes.
- Gain expertise in Euler's totient, Fermat's, Euler's and Wilson's Theorems and work on applications illustrating them.
- Solve congruences as application of Chinese remainder Theorem.
- Understand number theory from algebraic point of view there by improving their sense of abstraction.
- Discuss Quadratic residue and Jacobi symbol and work on sum of two squares problems.
- Attained mastery in the fundamentals of greatest integer function and recurrence functions and attacking combinatorial problems using them.
- Solve simple simultaneous linear Diophantine equations.

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Second Year | **ELECTIVE COURSE III** | **Semester: III**

1) INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS

Code: | **(Theory)** | **Credit: 4**

COURSE OBJECTIVES:

- To obtain thorough analysis of various aspects of calculus of variations.
- To acquire the knowledge of solving problems in the fields of mechanics and mathematical physics.

CALCULUS OF VARIATIONS

UNIT – I:

Problems with fixed boundaries.

UNIT – II:

Problems with moving boundaries - Externals with corners - One sided variations.

UNIT – III:

Sufficient conditions for Extremum - Conditional Extremum Problems.

INTEGRAL EQUATIONS

UNIT – IV:

Linear Integral Equations - Definition, Regularity conditions - special kind of kernels - eigen values and eigen functions - convolution Integral - the inner and scalar product of two functions - Notation - reduction to a system of Algebraic equations - examples – Fredholm alternative - examples - an approximate method.

UNIT – V:

Method of successive approximations: Iterative scheme - examples - Volterra Integral equation - examples - some results about the resolvent kernel. Classical Fredholm Theory: the method of solution of Fredholm - Fredholm's first theorem - second theorem - third theorem.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Variational problems in fluid flow and Heat transfer.

REFERENCES:

- Ram. P. Kanwal - Linear Integral Equations Theory and Practice, Birkhauser Boston, 2012.

- L. Elsgolts, Differential equations and the calculus of variations, University Press of the Pacific, 2003.
  UNIT – I Chapter 6 of (2)
  UNIT – II Chapter 7,8 of (2)
  UNIT – III Chapter 9,10 of (2)
  UNIT – IV Chapter 1,2 of (1)
  UNIT – V Chapter 3,4 of (1)
- S.J. Mikhlin, Linear Integral Equations (translated from Russian), Hindustan Book Agency, 1960.
- I.N. Snedden, Mixed Boundary Value Problems in Potential Theory, North Holland, 1966.
- https://www.researchgate.net/file.PostFileLoader.html?id=56c4564d5cd9e3c21f8b457e&assetKey=AS:330076274085892@1455707725045
- https://www.researchgate.net/profile/Andrei-Polyanin/publication/275518932_Handbook_of_Integral_Equations_Second_Edition/links/5657321b08aeafc2aac0c490/Handbook-of-Integral-Equations-Second-Edition.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand the concepts of variation and its properties.
- Use Euler's equation to solve various types of variational problems with fixed boundaries.
- Modify the Euler's formula for a class of curves with moving boundary points.
- Solve problems related with reflection and refraction, diffraction of light rays.
- Derive sufficient conditions based on second variation.
- Classify Fredholm, Volterra and singular type integral equations.
- Solve integral equations using Fredholm theorem, Fredholm Alternative theorem and method of successive approximations.
- Understand the classical Fredholm theory.

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Second Year **ELECTIVE COURSE III** **Semester: III**

2) FINANCIAL MATHEMATICS

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To study financial mathematics through various models.
- To study the various aspects of financial mathematics.

UNIT – I:

Single Period Models: Definitions from Finance - Pricing a forward - One-step Binary Model - a ternary Model - Characterization of no arbitrage - Risk-Neutral Probability Measure.

UNIT – II:

Binomial Trees and Discrete Parameter Martingales: Multi-period Binary model - American Options - Discrete parameter martingales and Markov processes - Martingale Theorems - Binomial Representation Theorem - Overture to Continuous models.

UNIT – III:

Brownian Motion: Definition of the process - Levy's Construction of Brownian Motion - The Reflection Principle and Scaling - Martingales in Continuous time.

UNIT – IV:

Stochastic Calculus: Non-differentiability of Stock prices - Stochastic Integration - Ito's formula - Integration by parts and Stochastic Fubini Theorem - Girsanov Theorem - Brownian Martingale Representation Theorem – Geometric Brownian Motion - The Feynman - Kac Representation.

UNIT – V:

Block-Scholes Model: Basic Block-Scholes Model - Block-Scholes price and hedge for European Options - Foreign Exchange - Dividends - Bonds - Market price of risk.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Large Deviations Principles

REFERENCES:

1. Alison Etheridge, A Course in Financial Calculus, Cambridge University Press, Cambridge, 2002.
   UNIT – I Chapter 1
   UNIT – II Chapter 2
   UNIT – III Chapter 3

UNIT – IV Chapter 4
UNIT – V Chapter 5
2. Martin Boxter and Andrew Rennie, Financial Calculus: An Introduction to Derivatives Pricing, Cambridge University Press, Cambridge, 1996.
3. Damien Lamberton and Bernard Lapeyre, (Translated by Nicolas Rabeau and Farancois Mantion),
4. Introduction to Stochastic Calculus Applied to Finance, Chapman and Hall, 1996.
5. Marek Musiela and Marek Rutkowski, Martingale Methods in Financial Modeling, Springer Verlag, New York, 1988.
6. Robert J.Elliott and P. Ekkehard Kopp, Mathematics of Financial Markets, Springer Verlag, New York, 2001 (3rd Printing)
7. https://archive.org/details/financialmathema032436mbp

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Use discrete and continuous processes in financial modeling.
- Gain knowledge in the relationship between stochastic and deterministic models.
- Understand the roles of Put and Call options in risk reduction also understand hedging strategies to reduce risk.
- Understand the role of the Black-Scholes partial differential equation and its boundary and final conditions in option pricing.

*****

Second Year **ELECTIVE COURSE III** **Semester: III**

3) COMBINATORICS

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To introduce the notion of different types of distributions of objects and generating functions.
- To study the Polya's enumeration theorems.

UNIT – I:

Permutations and combinations - distributions of distinct objects ~ distributions of non-distinct objects - Stirlings formula.

UNIT – II:

Generating functions. - generating function for combinations - enumerators for permutations - distributions of distinct objects into non-distinct cells - partitions of integers – the Ferrer's graphs - elementary relations.

UNIT – III:

Recurrence relation - linear recurrence relations with constant coefficients solutions by the technique of generating functions - a special class of nonlinear difference equations - recurrence relations with two indices.

UNIT – IV:

The principle of inclusion and exclusion - general formula - permutations with restriction on relative positions - derangements - the rook polynomials - permutations with forbidden positions.

UNIT – V:

Polya's theory of counting - equivalence classesunder a permutation group Burnside theorem - equivalence classes of functions - weights and inventories of functions - Polya' s fundamental theorem – generation of Polya's theorem.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Catalan numbers and their generalizations & partitions.

REFERENCES:

1. Introduction of Combinatorial Mathematics, C.L. Liu, McGraw Hill,1968.
   UNIT – I Chapter 1
   UNIT – II Chapter 2
   UNIT – III Chapter 3
   UNIT – IV Chapter 4
   UNIT – V Chapter 5

2. Marshall Hall Jr., Combinatorial Theory, John Wiley & Sons, second edition.
3. H.J. Rayser, Combinatorial Mathematics, Carus Mathematical Monograph, No.14.
4. https://users.math.msu.edu/users/bsagan/Books/Aoc/final.pdf
5. https://opentext.uleth.ca/PDF/Combinatorics.pdf

Course Outcomes:

At the end of the course, students will be able to:

- Review and explain the techniques required in addressing problems on permutations and combinations. For illustration, finding how the distribution of distinct objects into non distinct cells are made helps the students to gain the impetus of the subject.
- Explain how the technique of generating functions and recurrence functions are used to solve the problems in combinatorics.
- Detail about simultaneous recurrences and use it to solve more problems.

*****

Second Year | **NON MAJOR ELECTIVE II** | **Semester: III**

MATHEMATICS FOR COMPETITIVE EXAMINATION

Code: | **(Theory)** | **Credit: 2**

COURSE OBJECTIVES:

- To gain quantitative aptitude required in the present scenario.
- To emphasize the right perceptive needed to crack such problems and understand the recurring pattern in those problems.

UNIT – I:

Problems on Numbers- Average-Problems on Ages.

UNIT – II:

Percentage-Profit & Loss-Simple Interest-Compound Interest.

UNIT – III:

Ratio & Proportion-Partnership-Calender-Clocks.

UNIT – IV:

Time and work-Pipes & Cistern.

UNIT – V:

Time & Distance-Problems on Trains-Boats and Streams.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Simple problems using sets, functions, group theory etc.

REFERENCES:

1. Dinesh Khattar, The Pearson Guide to Quantitative Aptitude for Competitive Examinations, Pearson Education, 3 edition, 2015.

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Face competitive examinations with confidence.
- Solve a lot of problems on numbers and averages and problems on ages.
- Get a lot of training on percentage, profit and loss.
- Crack problems on calculating simple interest and compound Interest.
- Work on a plenty of problems on time and work.
- Get working knowledge on ratios and proportions.
- Calculate time, distance, speed given the other two and solve lot of problems.
- Acquire problem solving ideas on trains, boats and streams.

*****

Second Year **VALUE ADDED COURSE II** **Semester: III**

1) MATHEMATICS FOR COMPETITIVE EXAMINATIONS

Code: **(Theory)** **Credit: 2**

COURSE OBJECTIVES:

- To gain quantitative aptitude required in the present scenario.
- To emphasize the right perceptive needed to crack such problems and understand the recurring pattern in those problems.

UNIT – I:

Problems on Numbers- Average-Problems on Ages.

UNIT – II:

Percentage-Profit & Loss-Simple Interest-Compound Interest.

UNIT – III:

Ratio & Proportion-Partnership-Calender-Clocks.

UNIT – IV:

Time and work-Pipes & Cistern.

UNIT – V:

Time & Distance-Problems on Trains-Boats and Streams.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only):

Simple problems using sets, functions, group theory etc.

REFERENCES:

1. Dinesh Khattar, The Pearson Guide to Quantitative Aptitude for Competitive Examinations, Pearson Education, 3 edition, 2015.

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Face competitive examinations with confidence.
- Solve a lot of problems on numbers and averages and problems on ages.
- Get a lot of training on percentage, profit and loss.
- Crack problems on calculating simple interest and compound Interest.
- Work on a plenty of problems on time and work.
- Get working knowledge on ratios and proportions.
- Calculate time, distance, speed given the other two and solve lot of problems.
- Acquire problem solving ideas on trains, boats and streams.

*****

Second Year **VALUE ADDED COURSE II** **Semester: III**

2) INTRODUCTION TO SAGEMATH

Code: **(Theory)** **Credit: 2**

COURSE OBJECTIVES:

- To learn one of the powerful open source software
- To visualize the mathematical concepts
- To train the students to become a professional mathematician

UNIT – I:

Using sagemath as an advanced engineering calculator.Evaluation of elementary functions (polynomials, square root, trigonometric, exponential, logarithmic etc.)Basic usage in Combinatorics& Number theory.

UNIT – II:

Plotting: simple plots of known functions, polar plotting, plotting implicit functions, contour plots, level sets, parametric 2D plotting, vector fields plotting, gradients.

UNIT – III:

Advanced plotting 3D plots.

UNIT – IV:

Basic usages in Linear Algebra and Vector Calculus.

UNIT – V:

Basic usage in Real Analysis and Algebra.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Learning advanced computing in topics selected areas like numerical analysis, linear algebra, number theory, coding theory, cryptography, and graph theory.

REFERENCES:

1. Gregory V. Bard. Sage for Undergraduates, American Mathematical Society, available online at http://www.gregorybard.com/Sage.html
2. Tuan A. Le and Hieu D. Nguyen. SageMath Advice For Calculus available online at http://users.rowan.edu/~nguyen/sage/SageMathAdviceforCalculus.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Students will be comprehend the theoretical concept and visualize them in much better way.
- Plotting tools helps students to get easier plots and include it in their project cum paper work.
- Evaluate elementary functions such as polynomials, square root, trigonometric, exponential, logarithmic etc.
- Work on basic number theoretic concepts such as checking whether a number is prime, performing congruences etc.
- Attain mastery in various 2d and 3d plots, viz., simple plot, polar plot, implicit plot etc.
- Use the plotting ideas and others to work on basic real analysis problems.
- Gain expertise on the computations involving matrices and linear algebra in general.
- Compute the basic group theoretic examples in algebra.

*****

Second Year | **CORE COURSE VIII** | **Semester: IV**

FUNCTIONAL ANALYSIS

Code: | **(Theory)** | **Credit: 5**

COURSE OBJECTIVES:

- To introduce Banach spaces and Hilbert spaces.
- To study fundamental theorems of functional analysis that includes Hahn Banach theorem, Open mapping theorem and Uniform boundedness principle and introduce operator theory and Banach algebras leading to the spectral theory of operators.

UNIT – I:

Banach Spaces: The definition and some examples – Continuous linear transformations – The Hahn-Banach theorem.

UNIT – II:

Banach Spaces: The natural embedding of N in N** – The open mapping theorem – The conjugate of an operator.

UNIT – III:

Hilbert Spaces: The definition and some simple properties – Orthogonal complements – Orthonormal sets – The conjugate space H*.

UNIT – IV:

Hilbert Spaces: The adjoint of an operator – Self-adjoint operators – Normal and unitary operators – Projections.

UNIT – V:

General Preliminaries on Banach Algebras: The Definition and some examples – Regular and singular elements – Topological divisors of zero – The spectrum– The formula for the spectral radius – The radial and semi-simplicity.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Generating topologies -Weak and Weak Topologies - Banach-Alaoglu Theorem.

REFERENCES:

1. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw -Hill, 2004.
UNIT – I Chapter 9 Sec 46 to 48
UNIT – II Chapter 9 Sec 49 to 51
UNIT – III Chapter 10 Sec 52 to 55
UNIT – IV Chapter 10 Sec 56 to 59
UNIT – V Chapter 12 Sec 302 to 317.

2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & sons, 1978.
3. G. Bachman and Lawrence Narici, Functional Analysis, Dover Publications, 2000.
4. H. C. Goffman and G. Fedrick, First course in Functional Analysis, Prentice Hall of India, New Delhi, 1987.
5. E. Taylor and D. C. Lay, Introduction to Functional Analysis, second edition, John Wiley & Sons, 1980.
6. Bollabas, Linear Analysis - An introductory course, Cambridge University Press (Indian edition), 1999.
7. V. Limaye, Functional Analysis, Revised Third Edition, New Age International, 2017.
8. M. Thamban Nair, Functional Analysis - A First Course, Prentice Hall of India, 2010.
9. S. Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, 2002.
10. https://59clc.files.wordpress.com/2012/08/functional-analysis-_-rudin-2th.pdf
11. https://people.math.ethz.ch/~salamon/PREPRINTS/funcana.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Identify Banach spaces and analyse their properties with other types of spaces.
- Examine and identify properties of complex Banach spaces- Hilbert spaces.
- Apply the analytical techniques and theoretical knowledge in Hilbert Spaces. Findout and determine orthonormal sets.
- Explain various properties of Hilbert spaces.
- Attain knowledge and experience of working with many pure mathematical problems.

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Second Year **CORE COURSE IX** **Semester: IV**

DIFFERENTIAL GEOMETRY

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To introduce the notion of surfaces and their properties.
- To study geodesics and differential geometry of surfaces.

UNIT – I:

Space Curves: Definition of a space curve - Arc length - tangent - normal and binormal - curvature and torsion - contact between curves and surfaces- tangent surface- involutes and evolutes- Intrinsic equations - Fundamental Existence Theorem for space curves- Helics.

UNIT – II:

Intrinsic Properties of a Surface: Definition of a surface - curves on a surface - Surface of revolution - Helicoids - Metric- Direction coefficients - families of curves- Isometric correspondence- Intrinsic properties.

UNIT – III:

Geodesics: Geodesics - Canonical geodesic equations - Normal property of geodesics- Existence Theorems - Geodesic parallels - Geodesics curvature- Gauss- Bonnet Theorem - Gaussian curvature- surface of constant curvature.

UNIT – IV:

Non Intrinsic Properties of a Surface: The second fundamental form- Principal curvature - Lines of curvature - Developable – Developable associated with space curves and with curves on surface - Minimal surfaces - Ruled surfaces.

UNIT – V:

Differential Geometry of Surfaces: Compact surfaces whose points are umblics- Hilbert's lemma - Compact surface of constant curvature - Complete surface and their characterization - Hilbert's Theorem - Conjugate points on geodesics.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Elementary concepts from commutative algebra. The Gauss Bonet theorems.

REFERENCES:

1. T.J. Willmore, An Introduction to Differential Geometry, Oxford University Press,(17th Impression) New Delhi 2002. (Indian Print).
   UNIT – I Chapter I: Sections 1 to 9.
   UNIT – II Chapter II: Sections 1 to 9.
   UNIT – III Chapter II: Sections 10 to 18.

UNIT – IV Chapter III: Sections 1 to 8.
UNIT – V Chapter IV: Sections 1 to 8.

2. Struik, D.T. Lectures on Classical Differential Geometry, Addison - Wesley, Mass. 1950.
3. Kobayashi S. and Nomizu. K. Foundations of Differential Geometry, Interscience Publishers, 1963.
4. Wihelm Klingenberg: A course in Differential Geometry, Graduate Texts in Mathematics, Springer Verlag, 1978.
5. J.A. Thorpe Elementary topics in Differential Geometry, Under - graduate Texts in Mathematics, Springer - Verlag 1979.
6. https://www.pdfdrive.com/download.pdf?id=5949406&h=ec626392725b62c68c495d75f553f7fa&u=cache&ext=pdf
7. https://archive.org/details/differentialgeom003681mbp

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Have a solid understanding of the subjects, linear algebra, multivariable calculus and differential equations and a basic knowledge of theoretical physics.
- Sketch and workout graphs, level sets, tangent space and surfaces of given smooth maps.
- Good knowledge on calculus of vector fields.
- Understand how Gauss map helps to identify the surfaces that are mapped onto the unit n-sphere.
- Describe surfaces as a solution sets of differential equations.
- Exhibit geodesics on surfaces.
- Learn how parametrizations of plane curves can be used to evaluate integrals over the curve.
- Compute the Gaussian curvature of various surfaces.

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Second Year **CORE COURSE X** **Semester: IV**

FLUID DYNAMICS

Code: **(Theory)** **Credit: 5**

COURSE OBJECTIVES:

- To give the students an introduction to the behaviour of fluids in motion.
- To give the students a feel of the applications of Complex Analysis in the analysis of the flow of liquids.

UNIT – I:

Real Fluids and Ideal Fluids - Velocity of a Fluid at a point – Streamlines and Path lines: Steady and Unsteady Flows – The Velocity potential – The Vorticity vector – Local and Particle Rates of Change – The Equation of continuity – Worked examples – Acceleration of a Fluid – Conditions at a rigid boundary – General analysis of fluid motion – Pressure at a point in a Fluid at Rest – Pressure at a point in Moving Fluid – Conditions at a Boundary of Two Inviscid Immiscible Fluids – Euler's equation of motion – Bernoulli's equation – Worked examples.

UNIT – II:

Discussions of a case of steady motion under conservative body forces – Some potential theorems – Some Flows Involving Axial Symmetry – Some special two-Dimensional Flows-Impulsive Motion. Some three- dimensional Flows: Introduction – Sources, Sinks and Doublets – Images in a Rigid infinite Plane – Axi-Symmetric Flows; Stokes stream function.

UNIT – III:

Some Two- Dimensional Flows: Meaning of a Two- Dimensional Flow – Use of cylindrical polar co-ordinates – The stream function – The Complex Potential for Two- Dimensional, Irrotational , Incompressible Flow – complex velocity potentials for Standard Two Dimensional Flows – Some worked examples – The Milne- Thomson circle theorem and applications – The theorem of Blasius.

UNIT – IV:

The use of conformal Transformation and Hydro dynamical Aspects – Vortex rows. Viscous flow Stress components in a real fluid - relations between Cartesian components of stress - Translational Motion of Fluid element – The Rate of Strain Quadraic and Principle Stresses – Some further properties of the rate of strain quardric - Stress analysis in fluid motion – Relations between stress and rate of strain - The coefficient of viscosity and laminar flow – The Navier- Stokes equations of motion of a viscous fluid.

UNIT – V:

Some solvable problems in viscous flow – Steady viscous flow in tubes of uniform cross section – Diffusion of vorticity – Energy Dissipation due to viscosity – Steady Flow past a Fixed Sphere – Dimensional Analysis; Reynolds Number – Prandtl's Boundary Layer.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Gas Dynamics and Magneto hydrodynamics.

REFERENCES:

1. Text Book of Fluid Dynamics by F.Chorlton ,CBS Publishers & Distributors, New Delhi ,1985.
   UNIT – I Chapter 2 and Chapter 3: Sections 3.1 to 3.6
   UNIT – II Chapter 3: Sections 3.7 to 3.11 and
   Chapter 4: Sections 4.1,4.2,4.3,4.5
   UNIT – III Chapter 5: Sections : 5.1 to 5.9 except 5.7
   UNIT – IV Chapter 5: Section 5.10, 5.12 and
   Chapter 8: Sections 8.1 to 8.9
   UNIT – V Chapter 8: Sections 8.10 to 8.16.
2. Computational Fluid Dynamics: An Introduction, J.F. Wendt J.D. Anderson, G. Degrez and E. Dick, Springer – Verlag, 1996.
3. Computational Fluid Dynamics,The Basics with Applicatios, J. D. Anderson, McGraw Hill, 1995.
4. An Introduction to Fluid Mechanics, Foundation Books, G. K. Batchelor, New Delhi, 1984.
5. A Mathematical Introduction to Fluid Dynamics, A. J. Chorin and A. Marsden, Springer- Verlag, New York, 1993.
6. Foundations of Fluid Mechanics, S. W. Yuan, Prentice Hall of India Pvt Limited, New Delhi, 1976.
7. An Introduction to Fluid Dynamics, R. K. Rathy Oxford and IBH Publishing Company, New Delhi, 1976.
8. http://home.iitk.ac.in/~nikhilk/Book.pdf
9. http://www.issp.ac.ru/ebooks/books/open/Advanced_Fluid_Dynamics.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand the basic ideas of fluid velocity, streamlines and rotational and irrotationalflows.
- Understand the meanings of fundamental terms like pressure and body force.
- Develop special mathematical methods involving images and complex variables for incompressible fluids.
- Derive images in three dimension.
- Solve problems using Milne-Thomson circle theorem.
- Understand Navier's stokes of motion
- Unify many developed principles.
- Solve problems related with cosmic electrodynamics and nuclear engineering.

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Second Year | **ELECTIVE COURSE IV** | **Semester: IV**

1) THEORY OF PROBABILITY

Code: | **(Theory)** | **Credit: 4**

COURSE OBJECTIVES:

- To make the students to understand about fields, σ-fields and random variables.
- To enable the students to learn about expectations, convergence in random variables and distribution functions.

UNIT – I:

Fields and σ Fields: Class of events –Functions and Inverse functions – Random variables – Limits of random variables.

UNIT – II:

Probability Space: Definition of probability – some simple properties – discrete probability space – General probability space – Induced probability space.

UNIT – III:

Distribution functions: Distribution functions of a random variable – Decomposition of distributive functions-Distributive functions of vector random variables – Correspondence theorem.

UNIT – IV:

Expectation and Moments: Definition of Expectation –Properties of expectation – Moments, Inequalities.

UNIT – V:

Convergence of Random Variables: Convergence in Probability –Convergence almost surely – Convergence in distribution –Convergence in the rthmean - Convergence theorems for Expectations.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Usage of package R, Measure theoretic introduction to probability theory.

REFERENCES:

1. B.R. Bhat (2007), Modern Probability Theory, 3rd edition, New Age International private ltd, New Delhi.
   UNIT I - Chapter 1 and 2 Omit (1.1&1.2)
   UNIT II - Chapter 3 (Omit 3.6)
   UNIT III - Chapter 4
   UNIT IV - Chapter 5
   UNIT V - Chapter 6 (6.1-6.5)

2. Chandra T.K and Chatterjee D. (2003),A first course in probability , 2nd Edition, Narosa Publishing House, New Delhi.
3. Kailai Chung and Farid Aitsahlia, Elementary Probability, Springer Verlag 2003, New York.
4. Marek Capinski and Thomasz Zastawniak (2003), Probability through problems, Springer Verlag, New York.
5. Sharma .T.K. (2005), A text book of probability and theoretical distribution, Discovery publishing house, New Delhi.
6. https://faculty.math.illinois.edu/~r-ash/BPT/BPT.pdf
7. http://www.ru.ac.bd/stat/wp-content/uploads/sites/25/2019/03/101_06_Feller_An-Introduction-to-Probability-Theory-and-Its-Applications-Vol.-2.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand Probability axioms and find conditional probabilities for lot of cases
- Compute expectations and moments on a number of distributions.
- Gain mastery in the important probability distributions, viz., Binomial, Poisson and Normal.

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Second Year **ELECTIVE COURSE IV** **Semester: IV**

2) TENSOR ANALYSIS AND SPECIAL THEORY OF RELATIVITY

Code: **(Theory)** **Credit: 4**

COURSE OBJECTIVES:

- To introduce the notion of Tensor and study its properties.
- To study the theory of relativity.

UNIT – I:

Invariance - Transformations of coordinates and its properties - Transformation by invariance - Transformation by covariance and contra variance - Covariance and contra variance - Tensor and Tensor character of their laws - Algebras of tensors - Quotient tensors - Symmetric and skew symmetric tensors – Relative tensors.

UNIT – II:

Metric Tensor - The fundamental and associated tensors - Christoffel's symbols - Transformations of Chrisffel's symbols- Covariant Differentiation of Tensors - Formulas for covariant Differentiation- Ricci Theorem - Riemann -Christoffel Tensor and their properties.

UNIT – III:

Einstein Tensor- Riemannian and Euclidean Spaces (Existence Theorem) – The e-systems and the generalized Kronecker deltas - Application of the e-systems.

UNIT – IV:

Special Theory of Relativity: Galilean Transformation - Maxwell's equations - The ether Theory – The Principle of Relativity Relativistic Kinamatics : Lorentz Transformation equations - Events and simultaneity - Example Einstein Train - Time dilation - Longitudinal Contraction -Invariant Interval - Proper time and Proper distance – World line - Example - twin paradox - addition of velocities - Relativistic Doppler effect.

UNIT – V:

Relativistic Dynamics : Momentum – energy – Momentum-energy four vector – Force – Conservation of Energy – Mass and energy – Example – inelastic collision – Principle of equivalence – Lagrangian and Hamiltonian formulations. Accelerated Systems: Rocket with constant acceleration – example – Rocket with constant thrust .

UNIT – VI CURRENT CONTOURS(For Continuous Internal Assessment Only):

Relativistic kinematic and dynamic calculations,

REFERENCES:

1. I.S. Sokolnikoff, Tensor Analysis, John Wiley and Sons, New York, 1964
2. D. Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985

   UNIT – I   Chapter 2: Sections 18 to 28 of [1]
   UNIT – II   Chapter 2: Sections 29 to 37 of [1]
   UNIT – III   Chapter 2: Section 38 to 41 of [1]
   UNIT – IV   Chapter 7: Sections 7.1 and 7.2 of [2]
   UNIT – V   Chapter 7: Sections 7.3 and 7.4 of [2]
3. J.L. Synge and A.Schild, Tensor Calculus, Toronto, 1949.
4. A.S. Eddington, The Mathematical Theory of Relativity, Cambridge University Press, 1930.
5. P.G. Bergman, An Introduction to Theory of Relativity, New york, 1942.
6. C.E. Weatherburn, Riemannian Geometry and Tensor Calculus, Cambridge, 1938.
7. https://web.math.princeton.edu/~nelson/books/ta.pdf
8. https://www.f.waseda.jp/sidoli/Einstein_Relativity.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Understand tensor algebra and its applications in applied sciences and engineering.
- Know the fundamental mathematics of tensor that are important for higherlearning
- Work with some tools in branches of applied mathematics, physics and geophysics.
- Demonstrate knowledge and broad understanding of Special Relativity.
- Explain the meaning and significance of the postulate of Special Relativity.
- Explain true nature of Lorentz transformation and Doppler Effect.
- Explain relativistic momentum and Einstein field equations.

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Second Year | **ELECTIVE COURSE IV** | **Semester: IV**

3) ALGEBRAIC TOPOLOGY

Code: | **(Theory)** | **Credit: 4**

COURSE OBJECTIVES:

- To introduce the notion of homotopy and covering spaces.
- To study the Jordan Curve Theorem.

UNIT – I:

Homotopy of Paths-The Fundamental Group-Covering spaces.

UNIT – II:

The Fundamental group of the circle – The Fundamental group of the punctured plane- The Fundamental group of S^n.

UNIT – III:

Fundamental groups of surfaces- Essential and Inessential maps-The Fundamental theorem of algebra.

UNIT – IV:

Homotopy type – The Jordan separation theorem.

UNIT – V:

The Jordan Curve Theorem.

UNIT – VI CURRENT CONTOURS (For Continuous Internal Assessment Only):

Homology theory

REFERENCES:

1. Topology – A first course by James R.Munkres, Prentice-Hall of India Pvt Ltd, Third print.
   UNIT – I Chapter 9: Sections 51-53
   UNIT – II Chapter 9: Sections 54,55
   UNIT – III Chapter 9: Sections 56,59,60
   UNIT – IV Chapter 10: Sections 58,61
   UNIT – V Chapter 7: Sections 63
2. A basic course in Algebraic Topology by William S Massey, Springer, First Edition.
3. Lecture notes on Elementary Topology and Geometry (Under graduate Texts in Mathematics) by I.M. Singer and John A Thorpe, Springer-Verlag, New York.
4. Elements of Algebraic Topology by James R. Munkres ,Addition-Wesley Publishing Company-1984

5. Allen Hatcher, Algebraic Topology, Cambridge University Press, 2002.
6. https://pi.math.cornell.edu/~hatcher/AT/AT.pdf
7. https://www.maths.ed.ac.uk/~v1ranick/papers/diecktop.pdf

COURSE OUTCOMES:

At the end of the course, students will be able to:

- Review the basic topological concepts connecting geometry.
- Understand quotient topology and how the identification works.
- Discuss on the concept of homotopy and homotopy equivalence of topological spaces.
- Compute the fundamental groups of standard topological spaces.
- Learn thoroughly covering homotopy theorem.
- Appreciate and deduce the important Brouwer's fixed point theorem.

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Second Year **PROJECT** **Semester-IV**

Code: **Credit: 5**

Each candidate shall be required to take up a Project Work and submit it at the end of the final year. The Head of the Department shall assign the Guide who, in turn, will suggest the Project Work to the student in the beginning of the final year. A copy of the Project Report will be submitted to the University through the Head of the Department on or before the date fixed by the University.

The Project will be evaluated by an internal and an external examiner nominated by the University. The candidate concerned will have to defend his/her Project through a Viva-voce.

ASSESSMENT /EVALUATION /VIVA-VOCE:

1. PROJECT REPORT EVALUATION (Both Internal & External):

I.	Plan of the Project	- 20 marks
II.	Execution of the Plan/collection of Data / Organisation of Materials / Hypothesis, Testing etc and presentation of the report.	- 45 marks
III.	Individual initiative	- 15 marks

2. VIVA-VOCE / INTERNAL& EXTERNAL - 20 marks

TOTAL **- 100 marks**

PASSING MINIMUM:

	Vivo-Voce 20 Marks	**Dissertation 80 Marks**
Project	40% out of 20 Marks (i.e. 8 Marks)	40% out of 80 marks (i.e. 32 marks)

A candidate shall be declared to have passed in the Project work if he/she gets not less than 40% in each of the Project Report and Viva-voce but not less than 50% in the aggregate of both the marks for Project Report and Viva-voce.

A candidate who gets less than 40% in the Project must resubmit the Project Report. Such candidates need to defend the resubmitted Project at the Viva-voce within a month. A maximum of 2 chances will be given to the candidate.

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