ST. JOSEPH’S COLLEGE (AUTONOMOUS)

BENGALURU-27

Re-accredited with **‘A++’ GRADE with 3.79/4 CGPA** by NAAC Recognized by UGC as College of Excellence

DEPARTMENT OF MATHEMATICS

SYLLABUS FOR POSTGRADUATE PROGRAMME

For Batch 2021-2024

Part A

1	Title of the Academic Program	M.Sc Mathematics	
2	Program Code	**(To be given by Examination Section)**	
3	Name of the College	St. Joseph's College (Autonomous)	
4	Objective of the College	1. Academic Excellence 2. Character Formation 3. Social Concern	
5	Vision of the College	"Striving for a just, secular, democratic and economically sound society, which cares for the poor, the oppressed and the marginalized"	
6	Mission of the College	**M1**	St. Joseph's College (Autonomous) seeks to form men and women who will be agents of change, committed to the creation of a society that is just, secular and democratic.
		M2	The education offered is oriented towards enabling students to strive for both academic and human excellence.
		M3	The college pursues academic excellence by providing a learning environment that constantly challenges the students and supports the ethical pursuit of intellectual curiosity and ceaseless enquiry.
		M4	Human excellence is promoted through courses and activities that help students achieve personal integrity and conscientise them to the injustice prevalent in society.
7	Name of the Degree	Master of Science (M.Sc.,) in Mathematics	
8	Name of the Department offering the program	Mathematics	
9	Vision of the Department offering program	"The Department endeavors to be a center of excellence nurturing joyful curiosity in learning, enthusiastic creativity in research, passion to build a free, transparent and dynamic teaching learning community with a commitment to share and serve."	
10	Mission of the Department offering program	• Initiating students in the use of the power of abstraction. • Enable students to perceive, enjoy and create patterns and the relationships that underlie the structures of Mathematics. • Teach students to pose and solve meaningful Mathematical problems that delve into the service of humanity.	
11	Duration of the Program	2 years (Four semesters)	
12	Total No. of Credits	93	
13	Program Educational Objectives (PEOs)	**PEO 1**	The M.Sc programme is meticulously designed to impart essential knowledge in Mathematics with opportunities for specialization in all major areas of pure and applied mathematics as well as pursuing academic/industrial careers.
		PEO 2	The non-academic outreach activities associated with the programme aim to inculcate in students a basic sense of responsibility and empathy towards social issues.
		PEO 3	The teaching methodology (which focuses on the "why" rather than the "what"), adopted by faculty will instil a life-long learning attitude among students, to adopt new skills and techniques that will help overcome the problems that evolve with changing times.
		PEO 4	The teaching pedagogy will encourage students to engage in an active learning process.

14	Graduation Attributes		The Following graduate attributes reflect the particular quality and feature or characteristics of an individual, that are expected to be acquired by a graduate through studies at St. Joseph's College. ● **Disciplinary knowledge** ● **Critical thinking** ● **Problem solving** ● **Analytical reasoning** ● **Research-related skills** ● **Cooperation/Team work** ● **Reflective thinking** ● **Self-directed learning and Lifelong learner** ● **Moral and ethical awareness/reasoning**
15	Program Outcomes (POs)	**PO1**	Students would have developed the ability to formulate and structure mathematical arguments through logical and deductive thinking.
		PO2	Students would be competent in using programming languages like Python/ SageMath/R programming to solve problems related to the latest mathematical and industrial research.
		PO3	Students would be able to work well as a team.
		PO4	Students would be aware of their moral obligations to society and be willing to involve in tasks that work towards the greater good.

Part B

M.Sc. Mathematics Curriculum

Courses and course completion requirements	**No. of credits**
Mathematics	91
Open elective courses (non-professional)	02
Outreach activity	

SUMMARY OF CREDITS

DEPARTMENT OF MATHEMATICS (PG) (2021-2023)								
Semester 1	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MT 7121	Algebra I	60	04	04	30	70	100
Theory	MT 7221	Real Analysis	60	04	04	30	70	100
Theory	MT 7321	Linear Algebra	60	04	04	30	70	100
Theory	MT 7421	Ordinary Differential Equations	60	04	04	30	70	100
Theory	MT 7521	Discrete Mathematics and Graph Theory	60	04	04	30	70	100
Practical	MT 7P1	Linear Algebra and ODE with SageMath	33	03	02	15	35	50
Practical	MT 7P2	Graph Theory with SageMath	33	03	02	15	35	50
Total Number of credits:					**24**			
Semester 2	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hours /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MT 8121	Algebra II	60	04	04	30	70	100
Theory	MT 8221	Measure and Integration	60	04	04	30	70	100
Theory	MT 8321	Complex Analysis	60	04	04	30	70	100
Theory	MT 8421	Partial Differential Equations	60	04	04	30	70	100
Theory	MT 8521	Topology	60	04	04	30	70	100
Theory (SoftCore)	MT 8621	Statistics	45	03	03	15	35	50
Practical	MT 8P1	Statistics with R Programming	33	03	02	15	35	50

Total Number of credits:			**25**					
Semester 3	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hours /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MT 9121	Functional Analysis	60	04	04	30	70	100
Theory	MT 9221	Classical and Continuum Mechanics	60	04	04	30	70	100
Theory	MTDE 9321 OR MTDE 9421	Spectral Graph Theory OR Optimization Techniques	60	04	04	30	70	100
Theory	MTDE 9521 OR MTDE 9621	Commutative Algebra OR Numerical Analysis	60	04	04	30	70	100
Theory (Softcore)	MT 9721	Mathematical Methods	30	02	02	15	35	50
Practical	MT 9R1	Introduction to Mathematical Research	30	02	02	-	50	50
Theory (Open Elective)	MTOE 9721	Making the right decisions	30	02	02	15	35	50
Note: Students choose open electives from other departments.								
Total Number of credits:			**22**					
Semester 4	**Code Number**	**Title**	**No. of Hours of Instruction**	**No. of teaching hours a week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	MTDE 0121 OR MTDE 0221	Number Theory OR Advanced Graph Theory	60	04	04	30	70	100
Theory	MTDE 0321 OR MTDE 0421 OR	Algebraic Topology OR Basic Operator Theory OR	60	04	04	30	70	100

	MTDE 0521	Advanced Probability and Statistics						
Theory	MTDE 0621 OR MTDE 0721 OR MTDE 0821	Representation Theory OR Algebraic Geometry OR Fluid Mechanics	60	04	04	30	70	100
Theory	MTDE 0918 OR MTDE 01018	Differential Geometry OR Mathematical Modelling	60	04	04	30	70	100
Project	MT9R2	Project	30	02	06	-	100	100
		IGNITORS/ OUTREACH						
Total Number of credits:					**22**			
Total No. of Credits : 93								
KEY WORDS: DE – Departmental Elective and OE – Open Elective								

CORE COURSES (CC)	
Course Title	**Code Number**
Algebra I	MT 7121
Real Analysis	MT 7221
Linear Algebra	MT 7321
Ordinary Differential Equations	MT 7421
Discrete Mathematics and Graph Theory	MT 7521
Algebra II	MT 8121
Measure and Integration	MT 8221
Complex Analysis	MT 8321
Partial Differential Equations	MT 8421
Topology	MT 8521
Statistics	MT 8621
Functional Analysis	MT 9121
Classical and Continuum Mechanics	MT 9221

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)	
Course Title	**Code Number**
Spectral Graph Theory	MTDE 9521
Optimization Techniques	MTDE 9621
Commutative Algebra	MTDE 9321

Numerical Analysis	MTDE 9421
Number Theory	MTDE 0121
Advanced Graph Theory	MTDE 0221
Algebraic Topology	MTDE 0221
Basic Operator Theory	MTDE 0421
Advanced Probability and Statistics	MTDE 0521
Representation Theory	MTDE 0621
Algebraic Geometry	MTDE 0721
Fluid Mechanics	MTDE 0821
Differential Geometry	MTDE 0921
Mathematical Modelling	MTDE 01021

GENERIC ELECTIVE COURSES (GSE)/ Can include open electives offered	
Course Title	**Code Number**
Making the right decisions	MTOE 9721

SKILL ENHANCEMENT COURSE (SEC)	
Course Title	**Code Number**
Linear Algebra and ODE with SageMath	MT 7P1
Graph Theory with SageMath	MT 7P2
Statistics with R programing	MT 8P1
Introduction to Mathematical Research	MT 9R1

VALUE ADDED COURSES (VAC)	
Course Title	**Code Number**

Online courses offered or recommended by the department to be listed	
Course Title	**Code Number**

Course Outcomes and Course Content

Semester I

Semester	I
Paper Code	**MT 7121**
Paper Title	**Algebra I**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To learn the concept of group action and use it to deduce important theorems in group theory regarding Class Equation, Automorphism, Inner Automorphism, Sylow's Theorem and other standard results. To understand the concept of irreducibility of polynomials. To understand the concepts of Euclidean Domain (ED), Principal Ideal Domain (PID) and Unique Factorization Domain (UFD).

Syllabus:

Group Theory: (35 Hours)

Unit 1

Few examples of groups: Dihedral Groups, Symmetric Groups, Matrix Groups, Quaternion Groups.
Group actions: Revisiting Cosets and Lagrange's theorem , Example showing that the converse of Lagrange's theorem is not true. Definition of group action and examples, Permutation representations. Cayley's Theorem and its generalization, A subgroup of index p where p is the smallest prime dividing the order of the group is normal, Group Acting on themselves by Conjugation, Class Equation, Conjugacy in Symmetric Group, A_5 is a simple group. **(15 hours)**

Unit 2

Automorphisms: Automorphism group (Aut(G)), The quotient of a group by its center is isomorphic to a subgroup of Aut(G), Inner automorphism group, Computing Automorphism groups and Inner Automorphism groups, The automorphism group of finite cyclic group, Giving explicit descriptions of Automorphism groups.
Sylow's Theorem: Definition of p-subgroup, Sylow- p subgroup. Sylow's Theorem. Application of Sylow's Theorem: Groups of order pq, Groups of order 30, Groups of order 12, Groups of order p^2q, Groups of order 60. Simplicity of Alternating Group. Any simple group of order 60 is isomorphic to A_5.
Self Study: A_n is simple for $n \geq 5$. Sylow subgroups of D_{2n}, $S_n A_n$,$SL_n((F_p)$,and problems from Exercise 4.5 (Page-146) from Dummit and Foote
External Direct Product: Definition and examples of external direct products. Properties of external direct products.
Fundamental Theorem of Abelian Group: The fundamental theorem of finite abelian groups (without proof)

and related problems. Greedy algorithm and related problems. Isomorphism classes of finite abelian groups. The fundamental theorem of finitely generated abelian groups (without proof). **(20 hours)**

Ring Theory : (25 Hours)

Unit 4:

Polynomials Rings and Factorization of Polynomial Rings:: Polynomial ring, D[x] is an integral domain if D is an integral domain, Division algorithm. Remainder Theorem. Factor Theorem. Polynomials of degree n has at most n zeros counting multiplicity. Principal Ideal Domain (PID, If F is a field then F[x] is a PID. Irreducible and Reducible Polynomial. Reducibility Test for Degree 2 and 3 polynomials, Gauss. Primitive polynomial. Content of a polynomial. Gauss lemma. Mod-p irreducibility Test, Eisenstein's criterion. Cyclotomic Polynomial. Polynomial ring quotient an ideal generated by an irreducible polynomial is a field. Constructing fields with p^n elements, where p is a prime and n is an integer. **(12 hours)**

Unit 4:

Euclidean Domains(ED), Principal Ideal Domains(PID) and Unique Factorization Domain(UFD): Definition and Examples of ED, Non-Examples: $Z[x]$,$Z[\sqrt{-5}]$, Concept of Greatest Common Divisor(GCD), Algorithm to find GCD of two elements in a ED, Definition and Examples of PID, Non-Examples: $Z[x]$,$Z[\sqrt{-5}]$, GCD in a PID, Every nonzero prime ideal is a maximal ideal, If $R[x]$is a PID then R is a field, Definition of irreducible and prime elements, In an integral domain a prime element is always irreducible. In a PID an element is prime iff it is irreducible, Definition and Examples of UFD, GCD of two elements in a UFD.
Self Study: Every ED is a PID (The proof is similar to showing $Z[x]$is a PID), In a UFD a nonzero element is prime if and only if it is irreducible. Every PID is a UFD. **(13 hours)**

TEXT BOOKS:

1) D. S. Dummit and R. M. Foote. Abstract Algebra. Wiley. 2003
2) J. A. Gallian. Contemporary Abstract Algebra. 4th Edition. Narosa Publishing. 2011

REFERENCE BOOKS:

1) C. S. Musili. Rings and Modules . 2nd Revised Edition. Narosa Publishing House. 1994
2) I. N. Herstein. Topics in Algebra. 2nd Edition. Wiley. 1975
3) I. S. Luthar and I. B. S. Passi. Algebra Volume-I Groups. Narosa Publishing House. 2013
4) I. S. Luthar and I. B. S. Passi. Algebra Volume-II Rings. Narosa Publishing House. 20123
5) J. B. Fraleigh. A first course in Abstract Algebra. 7th Edition Pearson Education India. 2002
6) M. Artin . Algebra. 2nd Edition Pearson Education India. 2017
7) S. K. Mapa. Higher Algebra Abstract and Linear. Sarat Book House. 1972
8) S. Lang. Algebra. 3rd Edition. Springer. 2002

BLUE PRINT

Code number: MT 7121

Title of the paper: ALGEBRA I

Chapter / Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	15	20
2	20	40
3	12	20
4	13	20
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have developed good knowledge of Sylow's Theorems and irreducibility test for polynomials . Know the relation between ED, PID and UFD and different examples of them.
CO2	Understand the proofs of Sylow's Theorem, Fundamental Theorem of Abelian Group and the various irreducibility tests of polynomials.
CO3	Be able to apply Sylow's theorem to various problems in group theory, specially to check whether a group is simple and also to classify groups of certain orders. Be able to check the irreducibility of polynomials. Be able to check the nature (ED/PID/UFD) of a domain.
CO4	Be able to analyse which method of solution is the easiest to solve a given problem.
CO5	Be able to critique various proof methods for a particular theorem and explain why (or why not) one way is more useful than the other.
CO6	Be able to create examples and counter-examples particularly when working with the converse of certain theorems and implications.

Semester	**I**
Paper Code	**MT 7221**
Paper Title	**Real Analysis**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To comprehend the basics of Riemann Integration, improper integration and Sequences and Series of functions. To understand the fundamental concepts of metric spaces..

Syllabus:

Unit 1:

Riemann Integration: Partition of a closed bounded interval. Upper and lower Darboux sums and Darboux integrals. Examples of integrable and non-integrable functions. Criteria for integration. Continuous and monotonic functions are integrable. Squeeze theorem. Riemann sums and Riemann definition of integral. Equivalence of the two definitions. Properties of Riemann integral. Lebesgue criterion. Indefinite integral. Fundamental theorems of calculus and mean value theorems. Integration by parts. **(18 hours)**

Unit 2:

Sequence and Series of Functions: Pointwise convergence of sequence of functions. Different examples. Uniform convergence. Necessary sufficient conditions for uniform convergence. Uniform convergence and continuity. Uniform convergence and integration. Uniform convergence and differentiation. Weierstrass Approximation Theorem (without proof) and related problems. Power series. Radius of convergence. **(12 hours)**

Unit 3:

Countability: Finite, Infinite, Denumerable, Countable, Uncountable sets. Examples, non-examples and properties of these sets. Countable union of countable sets is countable. The real line is uncountable. Cardinality of sets and related results. Cantor's Theorem. **(8 hours)**

Unit 4:

Metric Spaces: Notion of a metric space and examples. Open and closed sets in a metric space. Interior, exterior and boundary point. Limit and cluster point. Closure of sets. Bounded sets. Distance between sets. Diameter of a set. Cantor's Intersection Theorem and its converse.

Complete Metric spaces: Sequences and subsequences in a metric space. Convergence of sequences in a metric space. Cauchy sequences in a metric space. Complete metric spaces. Subspaces of complete metric spaces. First and second category spaces. Baire's category theorem and its applications.

Continuous functions on metric spaces: Real valued continuous functions. Continuous functions between arbitrary metric spaces. Equivalent definitions of continuity. Examples of continuous functions. Uniform continuity. **(22 hours)**

TEXT BOOKS:

1) S. K. Mapa. Introduction to Real Analysis. 7th Edition. Sarat Book House. 2013
2) D. R. Sherbert and G. Bartle. Introduction to Real Analysis. 4th Edition. Wiley. 2014
3) D. Gopal, A. Deshmukh, A. S. Ranadive and S. Yadhav. An Introduction to Metric Spaces. 1st Edition. CRC Press. 2021

REFERENCE BOOKS:

1) W. Rudin. Principles of Mathematical Analysis. 3rd Edition. McGraw-Hill Education.1976
2) J. M. Howie. Real Analysis. Springer India. 2001
3) S. K. Berberian. A first course in Real Analysis. Springer India. 1994
4) S. R. Ghorpade and B. V. Limaye. A course in Calculus and Real Analysis. 1st Edition.Springer. 2006
5) S. Shirali and H. L. Vasudeva. Metric Spaces. Springer. 2006
6) C. C. Pugh. Real Mathematical Analysis. 2nd Edition. UTM Springer. 2002
7) G. F. Simmons. Introduction to Topology and Modern Analysis. Tata McGraw-Hill Edition. 2004
8) S. Kumaresan. Topology of Metric Spaces. 2nd Edition. Narosa. 2005
9) J. Munkres. Topology. 3rd Edition. PHI Learning Limited. 2012

BLUE PRINT

Code number: MT 7221

Title of the paper: REAL ANALYSIS

Chapter/ Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	18	30
2	12	20
3	8	10
4	22	40
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have good knowledge of the development of Riemann integration. Know the significance of uniform convergence over pointwise convergence of sequences/series of functions. Know examples and properties of finite, infinite, countable and uncountable sets as well as metric spaces.
CO2	Understand the geometry involved in the construction of the Riemann integral and in convergence. Understand the different techniques for checking if a given function is a metric and if a given set is countable/uncountable or open/closed.
CO3	Be able to apply the theorems learnt in each topic to solve problems.
CO4	Be able to analyse which method of solution is the easiest to solve a given problem.
CO5	Be able to critique various proof methods for a particular theorem and explain why (or why not) one way is more useful than the other.
CO6	Be able to create examples and counter-examples particularly when working with the converse of certain theorems and implications.

Semester	**I**
Paper Code	**MT 7321**
Paper Title	**Linear Algebra**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To study the general theory of vector spaces and linear transformations and understand different ways for representing linear transformations in simpler ways by means of matrices. To study vector spaces with some extra structures like inner product spaces, endomorphism rings, and some special type of linear transformations on some of these spaces like adjoint transformations, self-adjoint transformations, orthogonal transformations etc.

Syllabus:

Unit 1:

Vector spaces: Abstract Vector spaces – Definition and examples. Subspaces – Criterion for a subset to be a subspace, Examples, Union and Intersection of subspaces, Subspace generated by a set. Basis and dimension – Linear dependence and Independence, Definitions of a finite dimensional space, Basis and Dimension, Criterion for a subset to be a basis, Dimension of familiar subspaces. Linear transformations – Basic results, The rank-nullity theorem (Statement only), Algebra of linear transformations. Quotient spaces and the first Isomorphism Theorem (Statement only). Direct sum – Definition of internal direct sum and finding the dimension of direct sum of subspaces. Projection on a subspace along another subspace, The Idempotent operators. The matrix of a linear transformation. **(13 hours)**

Unit 2:

Canonical forms: Eigenvalues and eigenvectors – Definitions and basic results. The characteristic and minimal polynomials, Primary decomposition theorem, Annihilating polynomials, Cayley-Hamilton theorem, Computing minimal polynomials of some specific operators. Diagonalizable and Triangulable operators – Criteria for diagonalization and triangulability. The Jordan form – The generalized eigenvectors and eigenspaces, The main theorem on Jordan canonical forms (Statement only), Problems on computing Jordan forms. **(20 hours)**

Unit 3:

Inner Product Spaces: Inner products. Orthogonality. The Gram-Schmidt Orthogonalization Process. Orthogonal Complement. Adjoint of a linear operator. Self-adjoint and Normal operators. Unitary and Orthogonal matrices and Operator. Positive definite matrices. Test for positive definiteness. Polar and Singular value decomposition.

(22 hours)

Unit 4:

Bilinear forms and Quadratic forms: Bilinear forms and Quadratic forms - Definitions and Examples. The matrix of a bilinear form and problems. **(5 hours)**

TEXT BOOKS:

1) Vivek Sahai and Vikas Bist : Linear Algebra. 2nd Edition. Narosa Publishing House. 2013.
2) S. K. Mapa : Higher Algebra Abstract and Linear. revised 9th Edition. Sarath Book House. 2003.
3) A.J. Insel. L.E.Spence and S.Friedberg: Linear Algebra. 4th Edition. Pearson Education.2003.
4) G. Strang : Linear Algebra and Its Application. 4th Edition. Cengage Learning. 2006.

REFERENCE BOOKS:

1) A.R. Rao and P.Bhimasankaram : Linear Algebra. Hindustan Book Agency. Second Edition. 19 TRIM Series. 2010.
2) C. W. Curtis : Linear Algebra an Introductory Approach. 4th Edition. Springer. 1984.
3) D. C. Lay : Linear Algebra and its Application. 3rd Edition. Pearson Education India.2009.
4) Seymour Lipschutz : Theory and Problems of Linear Algebra. SI (metric) edition. Schaum's outline series. McGraw Hill Publications. 1987.
5) K. Hoffman and R. Kunze :Linear Algebra. 2nd Edition. Prentice Hall India Ltd. 1978.
6) S. Lang :Linear Algebra. 3rd Edition . 11th Printing. Springer. 2004.
7) S. Kumaresan : Linear Algebra-A geometric approach. Prentice Hall India Private Limited. 2000.
8) I.N.Herstein : Topics in Algebra. 2nd Edition. Wiley. 1975.

BLUE PRINT

Code number: MT 7321

Title of the paper: LINEAR ALGEBRA

Chapter/ Unit Number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	13	20
2	20	35
3	22	35
4	5	10
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have enhanced their knowledge of Linear Algebra by coming across a more general theory of Linear Algebra which is not restricted to finite dimensional vector spaces. Know more non-trivial examples of vector spaces and linear transformations and also know about vector spaces with some additional structures like inner product spaces, endomorphism rings of some fixed vector space etc.
CO2	Understand the crucial fact that to define a linear map, all one needs to do is to define any set theoretic map on a basis. Be able to understand the connection between algebra and geometry wherever possible.
CO3	Be able to apply the theorems learnt during the course for constructing algorithms for various computations.
CO4	Be able to analyze the given data and find ways for writing more efficient algorithms for computing the eigenvalues, for identifying the correct Jordan canonical form, for computing minimal polynomials etc.
CO5	-
CO6	-

Semester	**I**
Paper Code	**MT 7421**
Paper Title	**Ordinary Differential Equations**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To learn the basic techniques of solving ordinary differential equations and the stability of these solutions.

Syllabus:

Unit 1:

Introduction. Fundamental Theorem. First order linear differential equations. Linear dependence. Wronskian. Abel's formula. Fundamental sets of solution. Polynomial operators. Recap of Equations with constant coefficients, Equations of Cauchy type and Non-homogeneous equations. Method of Undetermined Coefficients. Mechanical Systems and Simple Harmonic Motion. Unforced Damped Vibrations. Forced Vibrations. Growth and Decay Phenomena. Mixing Phenomena. Cooling and Heating Phenomena. More Applications (Mechanics and Submarine search problem). **(15 hours)**

Unit 2:

A Review of Power Series. Series solutions. Solution at an ordinary point. Analyticity of solutions at an ordinary point. Regular singular points. Solution at a regular singular point. The method of Frobenius. The gamma function. Bessel's Equation. **(15 hours)**

Unit 3:

Introduction to eigenvalue problems. The adjoint equation. Boundary operators. Self-Adjoint eigenvalue problems. Properties of self-adjoint problems. Some special types of self-adjoint problems. Liovuelle's theorem. Singular problems. Some important singular problems. System of differential equations. First order systems. Systems with constant coefficients. Applications. **(15 hours)**

Unit 4:

Nonlinear differential equations. First order differential equations. Exact solutions. Some special type of second order equations. Existence and uniqueness of solutions. The Phase Plane. Critical points. Stability for nonlinear systems (Liapunov). Perturbed linear systems. Chaos and strange attractors. **(15 hours)**

TEXT BOOKS:

1) A. L. Rabenstein. An Introduction to Differential Equations. Academic Press. International Edition. 2014.
2) S. J. Farlow. An Introduction to Differential Equations and their Applications. Dover Publications Inc. 2006.

REFERENCE BOOKS:

1) A.C.King. J.Billingham and S.R.Otto. Differential equations. Cambridge University Press. 2006.
2) E.A. Coddington and N. Levinson. Theory of ordinary differential equations. McGraw Hill. 1955.
3) E.D. Rainville and P.E. Bedient. Elementary Differential Equations. McGraw Hill. New York. 1969.
4) G.F. Simmons. Differential Equations. Tata McGraw Hill Edition. New Delhi. 1974.
5) M.S.P. Eastham: Theory of ordinary differential equations. Van Nostrand. London. 1970.
6) S.L. Ross: Differential equations. John Wiley and Sons. New York. 3rd edition. 1984.

BLUE PRINT

Code number: MT 7421

Title of the paper: ORDINARY DIFFERENTIAL EQUATIONS

Chapter/Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	20	35
2	15	25
3	10	15
4	15	25
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Recognize and classify ordinary differential equations. Define Ordinary and Singular points of Differential Equations. Identify various methods to solve different kinds of ODE.
CO2	Interpret the type of solution of an ODE (for eg. Power series solution.) Understand how to find other solutions of an ODE if one of the solutions is given. Classify the 2 nd Order differential equations based on their properties and orthogonality
CO3	Apply the techniques such as the power series method, Green's function method or Lyopunov method to solve problems.
CO4	Analyze solutions of third order Differential equations, zeroes of solutions, critical points and their stabilities, and interpret it on the Phase plane.
CO5	-
CO6	-

Semester	**I**
Paper Code	**MT 7521**
Paper Title	**Discrete Mathematics and Graph Theory**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objectives:

To develop Mathematical maturity (i.e; the ability to understand and create mathematical arguments). To get an insight into how to utilize graph theoretical methods to analyse various connectivity patterns, data mining, image segmentation, clustering, image capturing and networking in the field of study and research. To acquire the knowledge of technical and non technical concepts of graph theory (in particular the theory of Digraphs) and its applications such as flow networks, neural networks in artificial intelligence, modelling bonds in chemistry and to be aware of scope of graph theory in research in education and related disciplines.

Syllabus:

Unit 1:

Discrete Mathematics:
Basic counting principles. The product rule and the sum rule. Examples to illustrate sum and product rule.
Recurrence relations. Modeling with recurrence relations with examples of Fibonacci numbers. Difference equations. Solving linear and non-linear recurrence relations.

Definition and types of relations. Representing relations using matrices and digraphs. Closures of relations. Paths in digraphs. Transitive closures. Warshall's Algorithm. Partial Orderings. Hasse diagrams. maximal and Minimal elements.
Self Study: Mathematical logic. Rules of inference. **(15 hours)**

Unit 2:

Fundamentals of graphs:
Definition of graph, Applications of graphs, Finite and Infinite graphs, Incidence and degree, Isolated vertex, Pendent vertex and Null graph. Directed graph, Types of digraphs, Digraphs and Binary relations, Directed paths and connectedness, Euler digraphs.
Paths and circuits:
Isomorphism, Subgraphs, A puzzle with multicolored cubes, Walks, Paths and Circuits, Connected graphs, disconnected graphs and components, Euler graphs, Operations on graphs, Hamiltonian paths and circuits, The travelling salesman problem. **(15 hours)**

Unit 3:

Trees, Cut sets and Matrix representation of graphs:
Trees, Some properties of trees, Pendent vertices in a tree, Distance and centers in a tree, Rooted and binary trees, On counting trees, Spanning trees, Fundamental Circuits, Finding all spanning trees of a graph, Spanning trees in a weighted graph. Cut sets, Some properties of a cut set, All cut sets in a graph, Fundamental circuits and cut sets, Connectivity and separability. Incidence matrix, Circuit matrix, Fundamental circuit matrix, Cut set matrix, Path matrix, Adjacency matrix.
(15 hours)

Unit 4:

Coloring and Matching:
Matchings, Maximum matching, Perfect matching, Hall's theorem, Edge independence number, Edge covering number, vertex independence number. Coloring, The Four color problem, Vertex coloring, Chromatic number, clique number, Edge coloring, Edge chromatic number, Konig's theorem, The five color theorem. Chromatic polynomial.
Domination concepts:
Open neighborhood, Closed neighborhood, Dominating sets in graphs, Minimum dominating sets, Domination number. **Self study**: Bounds of domination number in terms of size, order, degree, diameter. Minimal dominating sets. Total domination, Total domination number. **15 hours)**

TEXT BOOKS:

1) K. Rosen. Discrete Mathematics and its Applications. WCB McGraw-Hill. 7th edition. 2011.
2) N. Deo: Graph Theory: Prentice Hall of India Pvt. Ltd. New Delhi – 1990.
3) F. Harary: Graph Theory, Addison -Wesley,1969.
4) G. Chartrand and Ping Zhang: Introduction to Graph Theory. McGrawHill, International edition (2005)24.

REFERENCE BOOKS:

1) D.B.West, Introduction to Graph Theory,Pearson Education Asia, 2nd Edition, 2002.
2) Charatrand and L. Lesnaik- Foster: Graph and Digraphs, CRC Press (Third Edition), 2010.
3) T.W. Haynes, S.T. Hedetniemi and P. J. Slater: Fundamental of domination in graphs, Marcel Dekker. Inc. New York.1998.
4) J. Gross and J. Yellen: Graph Theory and its application, CRC Press LLC, Boca Raton, Florida, 2000.
5) Norman Biggs: Algebraic Graph Theory, Cambridge University Press (2nd Ed.)1996.
6) Godsil and Royle: Algebraic Graph Theory: Springer Verlag, 2002.
7) J.A.Bondy and V.S.R.Murthy: Graph Theory with Applications, Macmillan, London, (2004).
8) J.P. Tremblay and R.P. Manohar . Discrete Mathematical Structures with applications to computer science. McGraw Hill. 1975.
9) J.H.Van Lint and R.M. Wilson. A course on combinatorics. Cambridge University Press. 2006.

BLUE PRINT

Code number: MT 7521

Title of the paper: DISCRETE MATHEMATICS AND GRAPH THEORY

Chapter/Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
1	15	25
2	15	25
3	15	25
4	15	25
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have knowledge of discrete mathematics and graph theory techniques and ability to solve problems of computer science, networking and problems involved in different fields of study and research.
CO2	Understand problems of Engineering and physical sciences, express them in terms of graphs and use theoretical knowledge to get solutions.
CO3	Apply fundamental concepts, definitions, lemmas and theorems in the appropriate situations to establish results of their research work.
CO4	Analyse various practical problems of real life and use mathematical thinking to find the solution.
CO5	Evaluate and synthesize research articles which are published.
CO6	Create mathematical modelling for the purpose of simplified representation of reality, to mimic the relevant features of the system being analysed.

Semester	**I**
Paper Code	**MT 7P1**
Paper Title	**Linear Algebra and ODE with SageMath**
Number of teaching hours per week	03
Total number of teaching hours per semester	33
Number of credits	02

Objective of the paper:

To use SageMath, a Python based free and open source computer algebra system (CAS) to explore concepts in Applied Linear Algebra.

Syllabus:

Session 1: Visualization of Vectors in $\mathbb{R}^2$, Basic Operations, Linear Combination (Span), Vector Space over Different Fields, Subspace, Column Space and Row Space, Basis and Dimension, Rank and Kernel.

Session 2: Matrices over Rings such as $\mathbb{Z}$, $\mathbb{Q}$, $\mathbb{R}$, $\mathbb{C}$, Finite Fields etc. Row Echelon Form, Rank, Determinant, Inverse, Moore-Penrose Inverse.

Session 3: Eigenvalue and Eigenvector. Bounds of Eigenvalues. Gershgorin Disc Theorem, Interlacing Lemma, Courant-Fischer, Weyl and Cauchy Theorems.

Session 4: Special Types of Matrices: Circulant Matrices, Cauchy Matrix, Permutation Matrix, Vandermonde Matrices, Tridiagonal Matrices, Idempotent Matrices, Nilpotent Matrices, Permutation Matrices, Stochastic Matrices, Doubly Stochastic Matrix.

Session 5: Inner Product, Norm of Vectors, Gram-Schmidt Orthogonalization.

Session 6: Linear Transformation, Visualization of Linear Transformation, Rotation, Reflection, Scaling as a Linear Transformation.

Session 7: Matrix Decompositions I: Diagonalization, Singular Value Decomposition, Cholesky, LU Decomposition.

Session 8: Matrix Decompositions II: Rank Factorization, Jordan-Block Decomposition, Polar and Singular Value Decomposition.

Session 9: Linear Differential equations. Plotting analytic and numerical solutions to linear differential equations.

Session 10: Nonlinear Differential equations. Plotting the solution and critical points.

Semester	**I**
Paper Code	**MT 7P2**
Paper Title	**Graph Theory with SageMath**
Number of teaching hours per week	03

Total number of teaching hours per semester	33
Number of credits	02

Objectives:

To use SageMath, a Python based free and open source computer algebra system (CAS) to explore concepts in Graph Theory.

Syllabus:

Session 1: Introduction to graphs in SageMath: Visualization - Plotting special graphs such as cycles, path, complete graph, Petersen graph. Graph parameters - order, size, vertex degrees, connectedness. Checking whether a graph is Eulerian, regular, etc., using degrees.

Session 2: Directed graphs: Creating and plotting digraphs, finding the incidence matrix Q of a digraph with n vertices. Digraph parameters - Order, size, indegrees and outdegrees, degree sequences, weak and strong connectedness. Checking rank(Q) = n-1 for a weakly connected digraph.

Session 3: Operations on graphs: Adding, deleting vertices and edges, adding paths. Union and Intersection of graphs. Fusion of two vertices using vertex and edge deletion and addition.

Session 4: Travelling salesman problem using algorithm.

Session 5: Trees and distances: Creating and plotting trees using tree layout. Finding distances, eccentricities, radius, diameter Finding the centre of a tree.

Session 6: Finding a spanning tree, Finding a shortest spanning tree (optional).

Session 7: Graph connectivity: Checking whether a vertex (edge) is a cut vertex (cut edge). Find a cut set of the graph using edge_cut(). Find a minimum cut set of the graph using edge_cut().

Session 8: Matrices associated with graphs and their properties: (0,1) and (0,1,-1) incidence matrices, distance matrix, adjacency matrix and its powers. Compute the path matrix for a given pair of vertices using all_paths() (optional).

Session 9: Graph colouring and matchings: Find the chromatic number and chromatic polynomial of a graph, and verify the recurrence relation of the chromatic polynomial for a given pair of non-adjacent vertices. Find a maximum matching of a bipartite graph using matching(), and check whether it is a perfect matching.

Session 10: Covering, independence, and domination: Verify that a given graph has a covering if and only if it has no isolated vertex. Find a covering of a graph of order n and verify that it has at least ceil(n/2) edges, and that it includes all pendant edges. Find a maximal independent set by checking for dominance (optional).

Semester II

Semester	II
Paper Code	**MT 8121**
Paper Title	**Algebra-II**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

The core objective of the paper is to learn the elegant "Fundamental Theorem of Galois Theory" and to prove that a general quintic doesn't possess any formula (which involves addition, subtraction, multiplication, division and taking nth roots) to find its roots.

Syllabus:

Unit 1:

Chapter 1: Basic Theory of Field Extensions: Characteristic of a field, Degree of an extension, Any polynomial f over a field F has a root in an extension K of F. Field generated by elements. Explicit description of K (basis of K as a vector space and understanding K as adjoining a root of an irreducible factor of f to F.
Chapter 2: Algebraic Extensions: Definition of Algebraic element and minimal polynomial of an algebraic element. Important theorems related to algebraic elements and minimal polynomials. Understanding quadratic extension over a field of characteristic not equal to 2. An extension is finite iff it is generated by finitely many algebraic elements. The property of an extension being algebraic is transitive.
Chapter 3: Splitting Field and Algebraic Closure: Definition of splitting field of a polynomial over a field and existence of splitting field. Computing splitting fields of different polynomials over specified fields . Introducing cyclotomic fields as splitting fields of $x^n - 1$. Primitive roots of unity. Uniqueness of splitting field. Definition of algebraic closure of a field and algebraically closed field. Existence of an algebraically closed field (without proof).

(20 hours)

Unit 2:

Chapter 4: Separable Extensions: Definition of separable polynomial over a field. Derivative of a polynomial and criterion for a polynomial to be separable. Examples of separable and inseparable polynomials. Understanding when an irreducible polynomial is separable. Existence and Uniqueness of finite fields.
Chapter 5: Cyclotomic Polynomials: Defining the nth Cyclotomic Polynomial and computing cyclotomic polynomials. Proving that the nth cyclotomic polynomial is an irreducible monic polynomial of degree $\varphi(n)$ with integer coefficients.

(10 hours)

Unit 3:

Chapter 6: Automorphism group of a field extension: Computing the automorphism group of different extensions. Definition of Galois extension. Different examples and non-examples of Galois extension.
Chapter 7: Fundamental Theorem of Galois Theory: An extension is Galois if and only if it is the splitting field of a

separable polynomial. Fundamental Theorem of Galois Theory. Applying the fundamental theorem to find all the intermediate fields of different extensions. Finite fields over its prime sub-field are Galois extensions. **(20 hours)**

Unit 4:

Chapter 8: Insolvability of quintics: Cyclotomic Extensions, Abelian Extensions, Galois Group of Polynomials, Symmetric functions, Discriminant of a polynomial. Characterizing the Galois group of a polynomial through it's discriminant. A general polynomial of degree more than 4 can not be solved by radicals. **(10 hours)**

TEXT BOOKS:

1) D. S. Dummit and R. M. Foote. Abstract Algebra. Wiley. 2003
2) J. A. Gallian. Contemporary Abstract Algebra. . 4th Edition. Narosa Publishing. 2011

REFERENCE BOOKS:

1) I. N. Herstein. Topics in Algebra. 2nd Edition. Wiley. 1975
2) I. S. Luthar and I. B. S. Passi. Algebra Volume-IV Field Theory. Narosa Publishing House.2013
3) J. B. Fraleigh. A first course in Abstract Algebra. 7th Edition Pearson Education India.2002
4) M. Artin . Algebra. 2nd Edition Pearson Education India. 2017
5) S. Lang. Algebra. 3rd Edition. Springer. 2002

BLUE PRINT

Code number: MT 8121

Title of the paper: ALGEBRA II

Chapter/Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	20	30
2	10	20
3	20	30
4	10	20
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have developed good knowledge of Splitting fields, Separable extensions, Finite Fields, Automorphism groups of an extension.
CO2	Understand the Fundamental Theorem of Galois Theory and insolvability of quintics.
CO3	Be able to apply the theory to compute splitting fields of different polynomials and automorphism groups of different extensions. Be able to apply Fundamental Theorem of Galois Theory to compute intermediate fields of any extension and its properties.
CO4	Be able to analyse which method of solution is the easiest to solve a given problem.
CO5	Be able to critique various proof methods for a particular theorem and explain why (or why not) one way is more useful than the other.
CO6	Be able to create examples and counterexamples of field extensions and the automorphism group of them.

Semester	II
Paper Code	**MT 8221**
Paper Title	**Measure and Integration**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To comprehend the basics of sigma algebras, measurable spaces and measurable functions. To understand the failings of Riemann integrations and learn how the Lebesgue integral is a generalization of Riemann integration.

Syllabus:

Unit 1:

Lebesgue Measure:
Sigma algebras. Measures on a sigma algebra. Properties of a measure and Borel Cantelli Lemma. Lebesgue outer measure on R^n and its properties. Measurable sets. Lebegue measure on R^n. Properties of Lebesgue measure. Lebesgue sigma algebra. Non-measurable sets. Cantor set and sets of measure zero. Borel sets. Borel sigma algebra.

(15 hours)

Unit 2:

Measurable Functions:
Measurable functions. Examples of measurable functions. Properties of measurable functions. Characteristic functions and simple functions. Approximating measurable functions by simple functions. Littlewood's three principles (includes

Egorov's and Lusin's Theorems) **(15 hours)**

Unit 3:

Integration Theory:
Lebesgue Integral of simple functions and its properties. Lebesgue integral of bounded measurable functions supported on sets of finite measure and its properties. Bounded convergence theorem. Lebesgue integral on [a,b] is the same as Riemann integral. Lebesgue integral of non-negative measurable functions and its properties. Fatou's lemma and monotone convergence theorem. Lebesgue integral for any measurable function. Lebesgue (Dominated) convergence theorem. Invariance Properties of the integral. Fubini's Theorem (without proof) and its consequences. Product measure.
(15 hours)

Unit 4:

Differentiation:
Differentiation of Monotone functions. Vitali covering lemma. Functions of Bounded variation. Differentiability of an indefinite integral. Absolute continuity.
Lp spaces:
L^1spaces and Riesz-Fischer Theorem in L^1. L^pspaces. Holder and Minkowski inequalities. Convergence and completeness. Bounded linear functionals. Ries-Fischer theorem in L^p. Riesz representation theorem and its consequences.
(15 hours)

TEXT BOOKS:

1) E.M Stein and R. Shakarchi: Real Analysis - Measure Theory, Integration and Hilbert Spaces. New age international publishers. 2010
2) S. Kesavan: Measure and Integration. Hindustan Book Agency. 2019
3) H.L. Royden : Real Analysis, Macmillan, 1963

REFERENCE BOOKS:

1) P.R. Halmos : Measure Theory, East West Press, 1962
2) W. Rudin : Real and Complex Analysis, McGraw Hill , 1966
3) P. K. Jain, V. P. Gupta, P. Jain : Lebesgue Measure and Integration. Anshan Publications, 2nd edition. 2012.
4) M. M. Rao : Measure Theory and Integration. CRC press, 2nd edition. 2004.
5) F. Morgan : Geometric Measure Theory. Academic Press, 5th edition. 2016.

BLUE PRINT

Code number: MT 8221

Title of the paper: MEASURE AND INTEGRATION

Chapter/Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	15	25
2	15	25
3	15	25
4	15	25
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have developed good knowledge of the development of the Lebesgue integral. Know some of the failings of the Riemann theory and how Lebesgue theory compensates for them.
CO2	Understand the techniques involved in checking properties of measures, sigma algebras and measurable functions.
CO3	Be able to apply the theorems learnt in each topic to solve problems, particularly those involving the Littlewood's three principles.
CO4	Be able to analyse which method of solution is the easiest to solve a given problem.
CO5	Be able to critique various proof methods for a particular theorem and explain why (or why not) one way is more useful than the other.
CO6	-

Semester	**II**
Paper Code	**MT 8321**
Paper Title	**Complex Analysis**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To comprehend the basics of Analytic function, its properties and its behavior in various domains. To get an understanding of some standard results related to the analytic function define on the entire space and on a unit circle.

Syllabus:

Unit 1:

Analytic functions and the C-R equations. The Exponential, Sine and Cosine complex functions. Properties of Line integral. The closed curve theorem for Entire function. Cauchy Integral formula. Taylor series expansion of Entire function. Liouville Theorem. Fundamental Theorem of Algebra. Zeros of Analytic function. Gauss-Lucas Theorem. **(12 Hours)**

Unit 2:

Power series representation for Analytic function. Uniqueness theorem. Mean Value theorem. Maximum Modulus theorem. Minimum Modulus theorem. Critical points and Saddle points. Open Mapping theorem. Schwarz Lemma. Morera's theorem. **(14 Hours)**

Unit 3:

The General Cauchy Closed Curve theorem. Classification of Isolated singularities. Riemann Principle of Removable singularities. Casorati-Weistrass Theorem. Laurent Expansion. Winding Numbers and Cauchy Residue Theorem. Application of the Residue theorem. Argument principle. Rouche's Theorem. Hurwitz's theorem. **(18 Hours)**

Unit 4:

Evaluation of Definite Integral by Contour Integral Techniques. Application of Contour Integral Methods to Evaluation and Estimation of sums. Meromorphic functions. Conformal equivalence. Conformal Mapping. Reimann Mapping theorem. Harmonic functions. Mean-Value theorem for Harmonic Functions. **(16 Hours)**

TEXTBOOKS:

1) J. Bak and D.J. Newman, Complex Analysis, Springer. 2010.
2) E. Stein and R. Shakarchi, Complex Analysis, New Age International Publishers, 2010.

REFERENCE BOOKS:

1) J. B. Conway : Functions of one complex variable. Narosa. 1987.
2) L.V. Ahlfors : Complex Analysis. McGraw Hill. 1986.
3) T. W. Gamelin : Complex Analysis. Springer-Verlag. 2006.
4) R. Nevanlinna : Analytic functions. Springer. 1970.
5) E. Hille : Analytic Theory. Volume I. Ginn. 1959.
6) M. J. Ablowitz, A. S. Fokas : Complex Variables: Introduction and Applications. Cambridge Texts in Applied Mathematics. 2003.
7) S. Ponnuswamy : Foundations of Complex Variables. Alpha Science. 2nd edition.

BLUE PRINT

Code number: MT 8321

Title of the paper: COMPLEX ANALYSIS

Chapter/Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	12	20
2	14	24
3	18	30
4	16	26
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have developed a good knowledge about Analytic functions, its properties and its behavior in various domains. Students have basic knowledge of some standard results relating to it.
CO2	Have understood the geometrically the properties of the analytic functions. Students have understood the different techniques to check a given function is analytical. Students also have understood to methods to determine the zeros and residues of the analytic function
CO3	Students will be able to apply the concepts to solve problems.
CO4	Students will be able to analyze the methods of solutions to solve problems.
CO5	Students will be able to distinguish the methods to determine the zeros and residues of the analytic function and explain which methods are more suited
CO6	Students will be able to create different mappings between complex spaces.

Semester	**II**
Paper Code	**MT 8421**
Paper Title	**Partial Differential Equations**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To understand the basics of solving standard partial differential equations. Also, to learn various boundary value problems with their applications.

Syllabus:

Unit 1:

First Order Linear Partial Differential Equations:
Origin of partial differential equations. Lagrange's equation Pp+Qq=R and problems based on each type. Integral surface passing through a given curve. Surfaces orthogonal to a given curve. Geometrical description of solutions of Pp+Qq=R.
(5 hours)

Unit 2:

Second Order Linear Partial Differential Equations:
Linear, Non-Linear and Quasi linear PDEs. Superposition principle. Classification of second-order linear partial differential equations into hyperbolic, parabolic and elliptic PDEs. Reduction of 2nd order linear PDEs to canonical forms and their general solution. Solution of linear Homogeneous and Non-Homogeneous PDEs with constant coefficients, PDEs reducible to constant coefficients, variable coefficients. Monge's method of Integration with distinct intermediate integral. **(20 hours)**

Unit 3:

Heat, Wave and Laplace equations:
Solution of heat, wave and Laplace equations by the method of separation of variables and integral transforms. Cauchy Problem (D'Alembert's and Riemann Volterra method). Duhamel's principle for wave and heat equation. Dirichlet, Neumann and Mixed problems in a rectangle for Laplace equation. Solution of heat, wave and Laplace equations in cylindrical and spherical polar coordinates. **(25 hours)**

Unit 4:
Green's Function:
Method of Eigenfunctions of expansion and method of Green's function (Integral representation of the solution) for Heat equation, Wave equation and Laplace equation. **(10 hours)**

TEXT BOOKS:

1) M. D. Raisinghania. Advanced differential equations. S.Chand. 19th edition. 2018
2) K .S. Rao. Partial Differential Equations. PHI Learning Private limited. 3rd edition. 2013

REFERENCE BOOKS:

1) V. Sundarapandian. Ordinary and Partial differential equations. McGraw Hill. 2012
2) I. N. Sneddon. Elements of Partial Differential Equations. McGraw Hill Book company Inc. 2006
3) M. G. Smith. Introduction to the theory of partial differential equation. Van Nostrand.1967
4) F. Treves. Basic linear partial differential equations. Academic Press. 1975.
5) L. Debnath. Nonlinear PDEs for Scientists and Engineers. Birkhauser. Boston. 2007
6) F. John. Partial differential equations. Springer. 1971.

BLUE PRINT

Code number: MT 8421

Title of the paper: PARTIAL DIFFERENTIAL EQUATIONS

Chapter/Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	5	10
2	20	40
3	15	30
4	10	20
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have developed knowledge of first and second order partial differential equations along with different methods employed to obtain the solution for the same. Solution of heat, wave and Laplace equation are found under various boundary conditions involved.
CO2	Be able to understand different methods that can be incorporated to solve the multivariable function subjected to various boundary conditions.
CO3	Be able to apply Partial differential equations to linearize non-linear partial differential equation, find Laplace transform that is used to integrate the time dependence of the problem, solve linear boundary value problems using inverse Laplace transforms or Green's function method.
CO4	Be able to analyse qualitative properties involved in the solution of the problem and adopt a suitable method to find the solution.
CO5	Be able to evaluate the solution of the problem that involves multivariable functions. For instance, problems involving propagation of heat or sound, fluid flow, mass transfer, wave theory.
CO6	Be able to create equations that impose relations between various partial derivatives of a multivariable function.

Semester	**II**
Paper Code	**MT 8521**
Paper Title	**Topology**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To comprehend the basics of Riemann Integration, Sequences and Series of functions. To generalize the concept of distance in the real line and thus understand the notion of Metric Spaces.

Syllabus:

Unit 1:

Introduction to Topology:
Definition and examples of topological spaces. Basis for a topology. Product Topology (finite product only). Subspace Topology. Neighborhoods and Limit points. Closed Sets and Limit points. Closure, Interior and Boundary of a set. Hausdorff Space. **(12 hours)**

(Excluding the concept of finer and coarser, order topology, box topology)

Unit 2:

Continuous Functions:
Definition and examples of continuous function. Equivalent definitions of continuity. Homeomorphism and examples. Pasting lemma. Maps into Product Spaces. **(8 hours)**
Metric topology. Sequence Lemma. **(4 hours)**

Unit 3:

Connectedness and Compactness:
Definition and examples. Union of connected sets having a point in common is connected. Image of a connected space under a continuous map is connected. A cartesian product of connected space is connected. Path connected spaces. Example of a topological space which is connected but not path connected (topologist's sine curve). Components and path components.
(Excluding the concept of local connectedness)
Definition and Examples of Compact Spaces. Closed subspace of a compact space is compact. Compact subspace of a Hausdorff space is closed. Image of a compact set is compact under a continuous map. Tube lemma. The product of finitely many compact spaces is compact. Compactness and "finite intersection property". Compact subsets of real the line. Lebesgue number lemma. Uniform continuity and compactness. Limit point and sequential compactness.
(24 hours)
(Excluding the concept of local compactness.)

Unit 5:

Countability and Separation Axioms:
First countable and Second Countable topological space. Hausdorff Space. Regular Space. Normal Space. Necessary and Sufficient condition for Regular and Normal Spaces. Subspace of regular is regular and subspace of normal is normal. Urysohn's Lemma. Urysohn Metrization theorem. Tietze Extension Theorem (without proof). Tychnoff Theorem (without proof). **(12 hours)**

TEXT BOOKS:

1) J. Munkres. Topology. Pearson Education India. 2nd Edition. 2007

REFERENCE BOOKS:

1) J L. Kelley. General Topology. Van Nostrand. Princeton. 1955
2) J. B. Conway. A course in point set topology. UTM Series. Springer. 2013
3) K. D. Joshi. Topology. New Age International Private limited. 1983
4) M. A. Armstrong. Basic Topology. Springer India .1983.
5) G. F. Simmons. Introduction to Topology and Modern Analysis. Tata McGraw-Hill Education. 1963

BLUE PRINT

Code number: MT 8521

Title of the paper: TOPOLOGY

Chapter/Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	12	20
2	12	20
3	24	40
4	12	20
TOTAL	**60**	
Maximum marks for the paper (Excluding bonus question): **70**		

Course Outcomes: At the end of the Course, the Student should

CO1	Develop knowledge in basics, crucial definitions and theorems in topology and develop the ability to understand new definitions.
CO2	Understand the basics of the field of topology, with emphasis on those aspects of the subject that are basic to higher mathematics.
CO3	Be able to apply different proof writing techniques and write their own proofs
CO4	Be able to analyse which technique is most useful in demonstrating a particular property (openness, closedness, connectedness, compactness etc.) of a topological space.
CO5	Be able to critique various proof methods for a particular theorem and explain why (or why not) one way is more useful than the other.
CO6	Be able to create examples and counter-examples particularly when working with the questions on homeomorphisms, connected and compact spaces.

Semester	**II**
Paper Code	**MT 8621**
Paper Title	**Statistics**
Number of teaching hours per week	03
Total number of teaching hours per semester	45
Number of credits	03

Objective of the Paper:

To learn the basics of statistics and to know its applications.

Syllabus:

Unit 1:

Statistics: meaning and role as a decision-making science, Data-types and scales of measurement. Presentation: tables, diagrammatic and graphical methods. Exploratory Data Analysis using descriptive measures and graphical tools. Univariate Analysis: Measures of central tendency, positional averages, measures of dispersion, moments, skewness and kurtosis - Definition and properties. **(12 hours)**

Unit 2:

Probability theory: random experiment, simple events, sample space - types of events, probability of an event, rules of probability, conditional probability, Bayes' theorem.

Probability distributions: random variables - discrete and continuous type, probability distribution table, Probability Mass Function and Probability Density Function Bernoulli, Binomial, Poisson, Exponential and normal distributions - applications.
Sampling methods - population and sample, parameter and statistic, concept of a random sample, simple random sampling, stratified sampling, systematic sampling, sample size determination. **(13 hours)**

Unit 3:

Testing of hypothesis: null hypothesis, alternate hypothesis, test statistic, level of significance, p-value. Testing hypothesis about population mean, tests for proportions, test concerning variances.
Contingency tables, chi-square test for independence of attributes. Non Parametric Tests: One Sample Sign Test, One Sample Wilcoxon Test, Mann-Witney Test, Kolmogorov Smirnov Test.
Bivariate Analysis: Correlation: Scatterplot, correlation coefficient and its properties, rank correlation, Test for correlation coefficient
Regression: linear relationship, linear regression model, simple linear regression, fitting the regression model, coefficient of determination, Test for regression coefficients. **(20 hours)**

TEXT BOOKS:

1) S. C. Gupta, V. K. Kapoor. Fundamentals of Mathematical Statistics. Sultan Chand and Sons. 1st Edition. 2020.

REFERENCE BOOKS:

1) J. E. Freund, I. Miller, M. Miller. John E. Freund's Mathematical Statistics With Applications.7th Edition. Pearson Education India. 2004.
2) C. L. Liu. Elements of Discrete Mathematics. Tata McGraw-Hill. 2000.

BLUE PRINT

Code number: MT 8621

Title of the paper: STATISTICS

Chapter/Unit number	**Number of hours**	**Total marks for which the questions are to be asked (including bonus questions)**
1	12	15
2	13	15
3	20	20
TOTAL	**45**	
Maximum marks for the paper (Excluding bonus question): **35**		

Course Outcomes: At the end of the Course, the Student should

CO1	Have developed the basic knowledge of statistical methods and probability.
CO2	Understand the methods of Hypothesis testing.
CO3	Be able to apply different algorithms learnt to solve problems.
CO4	Analyse problems, arising in programming languages and to develop logical thinking and its applications of Discrete maths to the field of computer science.
CO5	-
CO6	-

Semester	I
Paper Code	**MT 7P2**
Paper Title	**Statistics with R Programming**
Number of teaching hours per week	03
Total number of teaching hours per semester	33
Number of credits	02

Objective of the paper:

To supplement the masters course with a basic knowledge of probability and statistics. To enable proficiency in the R programming.

Syllabus:

Session 1: Data Representation and Computation of Central Tendency: Collection of data through primary and secondary sources and their tabuation. Diagramatic Representation of Data: Histogram, Ogive Curves, Dot Plots, Box Plot, Stem and Leaf Radar Plot, Ternary Plot, Pie Chart, Bar Diagram.

Session 2: Measures of Central Tendency and Measures of Dispersion: Problems on Computation of Central Tendency. Problems on Properties of Central Tendency. Problems on Dispersion

Session 3: Relationships between Central Tendency, Moments, Skewness and Kurtosis: Problems on Relation between Mean, Median and Mode. Problems on Relationship between Arithmetic, Geometric and Harmonic Mean. Problems on Computation of Raw Moments and Central Moments. Problems on Computation of Skewness. Problems on Computation of Kurtosis.

Session 4: Probability: Problems on Conditional Probability. Problems on Bayes' Theorem. Problems on Computation of Probability using Bernoulli, Binomial, Poisson, Exponential and Normal Distribution.

Session 5: Probability Distributions: Construction of Probability Distribution Tables for Discrete Probability Distributions. Computation of Mean and Variance for Discrete Probability Distributions. Fitting of Data using Bernoulli, Binomial, Poisson, Exponential and Normal Distribution.

Session 6: Sampling Techniques:.Problems on Drawing Samples from a Given Population using Simple Random Sampling, Stratified Sampling, Systematic Sampling. Problems on Determination of Sample Size.

Session 7: Bi-Variate Data Analysis: *Partial Correlation. Multiple Correlation (Theory in lab)*. Problems on Computation of Correlation Coefficient (Karl Pearson's and Spearman's Coefficient of Correlation, Partial and Multiple Correlation). Problems on Fitting of Simple Linear Regression Model.

Session 8: Parametric Testing of Hypothesis - I. Problems on Test Concerning Population Mean. Problems on Test Concerning proportions. Problems on Test Concerning Variances.

Session 9: Parametric Testing of Hypothesis - II. *Chi-Square Test for Goodness of Fit (Theory in Lab)*. Problems on Test of Association of Attributes. Problems on the Test of Goodness of Fit. Problems on the Test for Correlation Coefficient. Problems on Test for Regression Coefficient.

Session 10: Non-Parametric Testing of Hypothesis: Problems on One Sample Sign Test. Problems on One Sample Wilcoxon Test. Problems on Mann-Witney Test. Problems on Kolmogorov Smirnov T.

MAPPING

Mapping OF Mission statements with Program Educational Objectives

Mission Statements	PEO1	PEO2	PEO3	PEO4	PEO5
M1					
M2					
M3					
M4					

(Tick mark or level of correlation: 3-High, 2-Medium, 1-Low can be used)

Mapping of PEOs with PSOs

PEOs/POs	PSO1	PSO2	PSO3	PSO4	PSO5
PEO1					
PEO2					
PEO3					
PEO4					
PEO5					

(**Tick mark or level of correlation:** 3-High, 2-Medium, 1-Low can be used)

Mapping of Course Outcomes to Program Outcomes

PEOs/POs	PSO1	PSO2	PSO3	PSO4	PSO5
CO1					
CO2					
CO3					
CO4					
CO5					
CO6					

(**Tick mark or level of correlation:** 3-High, 2-Medium, 1-Low can be used)

NOTE : Mapping of Course Outcomes to Program Learning Outcomes is written after every course