Pt.Ravishankar Shukla University Raipur

CURRICULUM & SYLLABI

(Based on CBCS & LOCF)

M.A./M.Sc. Mathematics

Semester System

Session: 2024-26

Approved by:	Board of Studies	Academic Council
Date:		

M.Sc. Mathematics

The Master of Science in Mathematics program is a two-year, four-semester program designed to provide students with a comprehensive understanding of advanced mathematical principles and their applications. Through a balanced curriculum covering diverse areas, students establish a strong foundational knowledge during the initial semesters. As the program progresses, students have the flexibility to tailor their learning by choosing specialized electives that align with their interests and career goals. Upon completion of the program, students will be well-prepared for diverse career paths, including academia, research, and technology sectors. With a solid mathematical background, they will excel as analytical thinkers and contribute effectively to various fields.

Program Outcomes:

Upon successful completion of the Master of Science in Mathematics program, students will be able to:

PO-1	**Knowledge:** Demonstrate a deep understanding of advanced mathematical concepts, theories, and techniques in various subfields of Mathematics.
PO-2	**Critical Thinking and Reasoning:** Exhibit advanced critical thinking skills by analyzing and evaluating mathematical arguments, theories, and proofs, and by making reasoned judgments about mathematical concepts and their implications.
PO-3	**Problem Solving:** Formulate abstract mathematical problems and derive solutions using rigorous logical reasoning. Demonstrate mastery in constructing mathematical proofs and justifications.
PO-4	**Advanced Analytical and Computational Skills:** Possess advanced skills in mathematical analysis and computation, including proficiency in using mathematical software, programming languages, and computational tools for numerical simulations and data analysis.
PO-5	**Effective Communication**: Communicate complex mathematical ideas and results effectively to both technical and non-technical audiences, through written reports, presentations, and teaching.
PO-6	**Social/ Interdisciplinary Interaction**: Integrate mathematical concepts and techniques into interdisciplinary contexts, collaborating effectively with professionals from other fields to address complex problems.
PO-7	**Self-directed and Life-long Learning**: Recognize the importance of ongoing professional development and lifelong learning in the rapidly evolving field of mathematics, and will exhibit the ability to continue learning independently or in formal educational settings.
PO-8	**Effective Citizenship**: **Leadership and Innovation:** Lead and innovate in various mathematical contexts, contributing to advancements in the field and applying mathematical insights to emerging challenges.
PO-9	**Ethics**: Demonstrate ethical and responsible conduct in mathematical research, teaching, and collaboration, adhering to professional standards and best practices.
PO-10	**Further Education or Employment:** Engage for further academic pursuits, including Ph.D. programs in mathematics or related fields. Get employment in academia, research institutions, industry, government, and other sectors.
PO-11	**Global Perspective**: Recognize the global nature of mathematical research and its impact, appreciating diverse cultural perspectives in mathematical practices.

PROGRAMME SPECIFIC OUTCOMES (PSOs) : At the end of the program, the student will be able to:

PSO1	Understand the nature of abstract mathematics and explore the concepts in further details.
PSO2	Apply the knowledge of mathematical concepts in interdisciplinary fields and draw the inferences by finding appropriate solutions.
PSO3	Pursue research in challenging areas of pure/applied mathematics.
PSO4	Employ confidently the knowledge of mathematical software and tools for treating the complex mathematical problems and scientific investigations.
PSO5	Qualify national level tests like NET/GATE etc.

M. Sc. MATHEMATICS

Specification of Course	Semester	No. of Courses	Credits
Core	I-IV	14	68
Elective	III-IV	06	30
Internship	II	01	02
Total		21	100
Additional Courses (Qualifying in nature, for Student admitted in School of Studies only)			
Generic Elective	II-III	02	06
Skill Enhancement (Value Added Courses)	I	01	02
Indian Knowledge System (IKS)	III	01	02

M.Sc. Mathematics

PROGRAMME STRUCTURE

Semester	Course Nature	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
							CIA	ESE	Total
Semester-I	Core	MAT110	Advanced Abstract Algebra (I)	T	6	5	30	70	100
	Core	MAT120	Real Analysis (I)	T	6	5	30	70	100
	Core	MAT130	Topology	T	6	5	30	70	100
	Core	MAT140	Advanced Complex Analysis (I)	T	6	5	30	70	100
	Core	MAT150	Advanced Discrete Mathematics (I)	T	5	4	30	70	100
Semester-II	Core	MAT210	Advanced Abstract Algebra (II)	T	6	5	30	70	100
	Core	MAT220	Real Analysis (II)	T	6	5	30	70	100
	Core	MAT230	General and Algebraic Topology	T	6	5	30	70	100
	Core	MAT240	Advanced Complex Analysis (II)	T	6	5	30	70	100
	Core	MAT300	Advanced Discrete Mathematics (II)	T	5	4	30	70	100
	Core	MAT260	Internship	T	§	2	30	70	100
Semester-III	Core	MAT310	Integration Theory and Functional Analysis (I)	T	6	5	30	70	100
	Core	MAT320	Partial Differential Equations & Mechanics (I)	T	6	5	30	70	100
	Elective-1 (Select any one)	MAT331	Fundamentals of Computer Science (OOPs and Data Structure)	T	4	3	30	50	100
				P	4	2	--	20	
		MAT332	Fuzzy Set Theory & Its Applications (I)	T	6	5	30	70	100
		MAT333	Mathematical Ecology	T	6	5	30	70	100
	Elective-2 (Select any one)	MAT341	Operations Research (I)	T	6	5	30	70	100
		MAT342	Wavelets (I)	T	6	5	30	70	100
	Elective-3 (Select any one)	MAT351	Programming in C (with ANSI Features) (I)	T	4	3	30	50	100
				P	4	2	--	20	
		MAT352	Graph Theory (I)	T	6	5	30	70	100
		MAT353	Number Theory ¶	T	6	5	30	70	100
Semester-IV	Core	MAT410	Functional Analysis (II)	T	6	5	30	70	100
	Core	MAT420	Partial Differential Equations & Mechanics (II)	T	6	5	30	70	100
	Elective-4 (Select any one)	MAT431	Operating System and Database Management System	T	4	3	30	50	100
				P	4	2	--	20	
		MAT432	Fuzzy Set Theory & Its Applications (II)	T	6	5	30	70	100

		MAT433	Mathematical Epidemiology	T	6	5	30	70	100
	Elective-5 (Select any one)	MAT441	Operations Research (II)	T	6	5	30	70	100
		MAT442	Wavelets (II)	T	6	5	30	70	100
	Elective-6 (Select any one)	MAT451	Programming in C (with ANSI Features) (II)	T	4	3	30	50	100
				P	4	2	--	20	
		MAT452	Graph Theory (II)	T	6	5	30	70	100
		MAT453	Cryptography ¶	T	6	5	30	70	100

§ Total 60 Hrs after examination of 2nd Semester. ¶ Offered to PG students in SoS only

Note:

1. In place of Elective Course Student can choose paper(s) from MOOC Courses (Swayam Portal) subject to the following conditions:
    a. The chosen paper will be other than the papers offered in the current course structure.
    b. The paper will be PG level with a minimum of 12 weeks' duration.
    c. The list of courses on SWAYAM keeps changing, the departmental committee will finalize the list of MOOC courses for each semester.
    d. The paper(s) may be chosen from Swayam Portal on the recommendation of Head of the Department.
2. The candidates who have joined the PG Programme in School of Studies (University Teaching Department), shall undergo Generic Elective Courses (only qualifying in nature) offered by other departments/SoS in Semester II and Semester III.
3. The candidates who have joined the PG Programme in School of Studies (University Teaching Department), shall undergo Course in Indian Knowledge System and Skill Enhancement Course/Value Added Course (only qualifying in nature) in Semester I and Semester III respectively.

Generic Elective Courses: (Offered to PG students of other Departments/SoS only)

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
II	MAT610	Elementary Mathematics for Social Sciences	T	2	2	30	70	100
III	MAT620	Mathematics for Social Sciences	T	2	2	30	70	100

Skill Enhancement/Value Added Courses: (Offered to the PG students of SoS in Mathematics)

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
I	MAT710	Typesetting in LATEX	P	4	2	30	70	100

Course on Indian Knowledge System: (Offered to the PG students of SoS in Mathematics)

Semester	Course Code	Course Title	Course Type (T/P)	Hrs/ Week	Credits	Marks		
						CIA	ESE	Total
III	MAT810	Indian Knowledge System (IKS)-Concepts and Mathematics Tradition	P	4	2	30	70	100

Programme Articulation Matrix:

Following matrix depicts the correlation between all the courses of the programme and Programme Outcomes

Course Code	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
MAT110	√	√	√	√	√	√	√	×	×	√	√	√	√	√	×	√
MAT120	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	√
MAT130	√	√	√	√	√	×	√	√	×	√	√	√	×	√	×	√
MAT140	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	√
MAT150	√	√	√	√	√	√	√	×	×	√	√	√	√	√	×	×
MAT210	√	√	√	√	√	√	√	×	×	√	√	√	√	√	×	√
MAT220	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	√
MAT230	√	√	√	√	√	×	√	√	×	√	√	√	×	√	×	×
MAT240	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	×
MAT250	√	√	√	√	√	√	√	×	×	√	√	√	√	√	×	×
MAT310	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	×
MAT320	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	√
MAT331	×	√	×	√	√	√	√	×	√	×	×	×	×	×	√	×
MAT332	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	×
MAT333	√	√	√	√	×	√	√	√	√	√	√	√	√	√	√	√
MAT341	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
MAT342	√	√	√	×	√	×	√	√	√	√	√	√	√	√	×	×
MAT351	√	√	√	√	√	√	√	√	√	√	√	√	√	×	√	×
MAT352	√	√	√	×	√	×	√	√	×	√	√	√	√	√	×	×
MAT353	√	√	√	×	√	√	√	√	×	√	√	√	√	√	×	√
MAT410	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	√
MAT420	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	√
MAT431	×	√	×	√	√	√	√	×	√	×	×	×	×	×	√	×
MAT432	√	√	√	√	√	√	√	√	×	√	√	√	√	√	×	×
MAT433	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×
MAT441	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
MAT442	√	√	√	×	√	×	√	√	×	√	√	√	√	√	×	×
MAT451	×	√	×	√	×	√	√	√	√	√	√	√	√	√	√	√
MAT452	√	√	√	×	√	×	√	√	×	√	√	√	√	√	×	×
MAT453	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	×
No. of courses mapping the PO/PSO	27	30	27	25	28	24	30	24	11	28	28	28	26	27	9	14

M.Sc. (Mathematics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	I
Course Code	Course Title		Course Type
MAT110	**ADVANCED ABSTRACT ALGEBRA (I)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--
Maximum Marks	CIA	ESE	
100	30	70	

Learning Objective (LO):

The course aims to equip students with a deep understanding of advanced algebraic concepts, particularly in groups and field theory, and empower them to apply this knowledge to solve mathematical problems and engage with higher-level algebraic research.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain normal and subnormal series of groups. Explore composition series and apply the Jordan-Holder theorem. Identify and analyze solvable and nilpotent groups.	Ap
2	Describe extension fields and distinguish algebraic and transcendental extensions. Analyze separable and inseparable extensions and explore their implications.	Ap
3	Identify and explain perfect fields, finite fields, and apply them to various mathematical problems. Discuss primitive elements and their significance in field theory. Explore algebraically closed fields and their properties.	U
4	Describe normal extensions, automorphisms of field extensions and their properties. Explain Galois extensions and their properties. Apply the Fundamental Theorem of Galois theory to relate field extensions and group structures.	An
5	Explain concept of solvability of polynomial by radicals. Express insolvability of the general equation of degree 5 by radicals. Observe limitations of solvability of certain polynomial by radicals.	U

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	3	1	-	-	-	3	1	-	-	-
CO2	3	3	3	1	1	1	3	-	-	-	-	3	2	-	-	3
CO3	3	3	3	1	1	1	3	-	-	2	-	3	2	-	-	2
CO4	3	3	3	1	1	2	3	1	-	2	1	3	2	-	-	-
CO5	3	3	3	1	1	-	2	-	-	2	2	3	2	3	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Groups - Normal and Subnormal series. Composition series. Jordan-Holder theorem. Solvable groups. Nilpotent groups.	15	1
II	Field theory- Extension fields. Algebraic and transcendental extensions. Separable and inseparable extensions.	15	2
III	Perfect fields. Finite fields. Primitive elements. Algebraically closed fields.	18	3
IV	Normal extensions. Automorphisms of extensions. Galois extensions. Fundamental theorem of Galois theory.	17	4
V	Solution of polynomial equations by radicals. Insolvability of the general equation of degree 5 by radicals.	10	5

Books Recommended:

1. P.B.Bhattacharya, S.K.Jain, S.R.Nagpaul, *Basic Abstract Algebra*, Cambridge University press, 1994
2. I.N.Herstein, *Topics in Algebra*, Wiley Eastern Ltd., 1999
3. Quazi Zameeruddin, Surjeet Singh, *Modern Algebra*, Vikas Publishing House Pvt. Ltd., 1990

Reference Books:

1. M.Artin, *Algebra*, Prentice -Hall of India, 1991.
2. P.M. Cohn, *Algebra*,Vols. I,II &III, John Wiley & Sons, 1982,1989,1991.
3. N.Jacobson, *Basic Algebra*, Vols. I , W.H. Freeman, 1980
4. S.Lang, *Algebra*, 3rd edition, Addison-Wesley, 1993.
5. I.S. Luther, I.B.S. Passi, *Algebra*, Vol. I-Groups, Vol.II-Rings, Narosa Publishing House (Vol.l-1996,Vol. II-1999)
6. D.S.Malik, J.N.Mordeson, M.K.Sen, *Fundamentals of Abstract Algebra*, Mc Graw-Hill, International Edition,1997.
7. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House, 1999.
8. I. Stewart, *Galois theory*, Chapman and Hall, 1989.
9. J.P. Escofier, *Galois theory*, GTM Vol.204, Springer, 2001.
10. J.B.Fraleigh, *A first course in Algebra*, Narosa,1982.

M.Sc. (Mathematics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	I

Course Code	Course Title	Course Type
MAT120	**REAL ANALYSIS (I)**	Core

Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The aim of this course to provide students a deep understanding of advanced topics in real analysis, enabling them to work with functions of several variables, convergence of series and sequences of functions, and apply these concepts to solve complex mathematical problems. Make them proficient in utilizing theorems and techniques related to differentiation and integration in multivariable calculus.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Distinguish pointwise and uniform convergence, apply the Cauchy criterion. Use Weierstrass M-test, Abel's and Dirichlet's tests, assess uniform convergence. Relate uniform convergence and continuity, uniform convergence and differentiation. Apply the Weierstrass approximation theorem.	**Ap**
2	Explore power series, their convergence properties and apply the uniqueness theorem for power series. Use Abel's and Tauber's theorems to examine convergence and summability of series. Explain rearrangements of series terms and apply Riemann's theorem.	**Ap**
3	Compute derivatives of functions of several variables in open subsets of R^n, applying chain rule, and computing partial derivatives. Compute derivatives of higher orders. Apply Taylor's, Inverse Function and Implicit Function Theorems.	**U**
4	Describe Jacobians and apply them in various contexts. Solve extremum problems with constraints, use Lagrange's multiplier method. Explore differentiation of integrals.	**An**
5	Explain partitions of unity and their applications. Analyze differential forms and their properties. Apply Stoke's theorem in higher dimension.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	3
CO2	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	3
CO3	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	2
CO4	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	2
CO5	3	3	3	1	2	1	2	1	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Sequences and series of functions, pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M-test, Abel's and Dirichlet's tests for uniform convergence, uniform convergence and continuity, uniform convergence and differentiation, Weierstrass approximation theorem.	18	1
II	Power series, uniqueness theorem for power series, Abel's and Tauber's theorems. Rearrangements of terms of a series, Riemann's theorem.	12	2
III	Functions of several variables, linear transformations, Derivatives in an open subset of R^n, Chain rule, Partial derivatives, interchange of the order of differentiation, Derivatives of higher orders, Taylor's theorem, Inverse function theorem, Implicit function theorem.	15	3
IV	Jacobians, extremum problems with constraints, Lagrange's multiplier method, Differentiation of integrals.	12	4
V	Partitions of unity, Differential forms, Stoke's theorem.	18	5

Books Recommended:

1. Walter Rudin, *Principle of Mathematical Analysis*, (3rd Edition) McGraw-Hill, Kogakusha, 1976.
2. H.L.Roydon, Real *Analysis*, Macmillan Pub.Co.Inc. (4th Edition), New York,1962.

Reference Books:

1. T.M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi,1985.
2. G. Klambauer, *Mathematical Analysis*, Marcel Dekkar,Inc. New York,1975.
3. A.J. White, *Real Analysis*: *an introduction*, Addison-Wesley Publishing Co., Inc.,1968.
4. G.de Barra, *Measure Theory and Integration*, Wiley Eastern Limited, 1981.
5. E. Hewitt and K. Stromberg, *Real and Abstract Analysis*, Berlin, Springer, 1969.
6. P.K. Jain and V.P. Gupta, *Lebesgue Measure and Integration*, New Age International Pvt. Ltd., New Delhi, 1986.
7. I.P. Natanson, *Theory of Functions of a Real Variable*. Vol. 1, Frederick Ungar Publishing Co., 1961.
8. R.L. Wheeden and A. Zygmund, *Measure and Integral: An Introduction to Real Analysis*, Marcel Dekker Inc.1977.
9. J.H. Williamson, *Lebesgue Integration*, Holt Rinehart and Winston, Inc. New York. 1962.

10. A. Friedman, *Foundations of Modern Analysis*, Holt, Rinehart and Winston, Inc., New York, 1970.
11. P.R. Halmos, *Measure Theory*, Van Nostrand, Princeton, 1950.
12. T.G. Hawkins, *Lebesgue's Theory, of Integration: Its Origins and Development*, Chelsea, New York, 1979.
13. K.R. Parthasarathy, *Introduction to Probability and Measure*, Macmillan Company of India Ltd., Delhi, 1977.
14. R.G. Bartle, *The Elements of Integration*, John Wiley & Sons, Inc. New York, 1966.
15. Serge Lang, *Analysis I & II*, Addison-Wesley Publishing Company, Inc. 1969.
16. Inder K. Rana, *An Introduction to Measure and Integration*, Norosa Publishing House, Delhi, 1997.
17. Walter Rudin, *Real & Complex Analysis*, Tata McGraw-Hill Publishing Co.Ltd. New Delhi, 1966.

M.Sc. (Mathematics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	I
Course Code	Course Title		Course Type
MAT130	**TOPOLOGY**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The aim of this course is to make students proficient in understanding of advanced concepts in topology, including set theory, topological spaces, compactness, connectedness, and various separation axioms. Make them able to understand different methods of defining topologies and be capable of proving theorems related to various topological properties.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain countable and uncountable sets, apply the Axiom of Choice, explain cardinal numbers and their arithmetic, prove the Schroeder-Bernstein theorem, Cantor's theorem, and the continuum hypothesis. State and prove Zorn's lemma and the well-ordering principle.	**Ap**
2	Explain topological spaces with examples, analyze bases and sub-bases, explain subspaces and relative topology. Characterize topological spaces in terms of Kuratowski Closure Operator and Neighborhood Systems. Analyze continuous functions and homeomorphisms.	**U**
3	Explain First and Second Countable spaces, Lindelof's theorems, and Separable spaces. Describe Separation axioms and their characteristics. State and prove Urysohn's lemma and Tietze extension.	**U**
4	Relate continuous functions and compact sets, Compactness and the finite intersection property. Illustrate sequentially and countably compact set. Explain local compactness, one-point compactification, and the Stone-Cech compactification.	**Ap**
5	Analyze Compactness in metric spaces. Explore equivalence between compactness, countable compactness, and sequential compactness. Explain Connected spaces, connectedness on the real line, Components and Locally connected spaces.	**An**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	3
CO2	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	1
CO3	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	-
CO4	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	-
CO5	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Countable and uncountable sets. Infinite sets and the Axiom of Choice. Cardinal numbers and its arithmetic. Schroeder-Bernstein theorem. Cantor's theorem and the continuum hypothesis. Zorn's lemma, well-ordering theorem.	15	1
II	Definition and examples of topological spaces. Bases and sub-bases. Subspaces and relative topology. Alternate methods of defining a topology in terms of terms of Kuratowski Closure Operator and Neighbourhood Systems. Continuous functions and homeomorphism.	19	2
III	First and Second Countable spaces. Lindelof's theorems. Separable spaces. Second countability and separability. Separation axioms; their Characterizations and basic properties. Urysohn's lemma, Tietze extension theorem.	19	3
IV	Compactness. Continuous functions and compact sets. Basic properties of Compactness. Compactness and finite intersection property. Sequentially and countably compact sets. Local compactness and one-point compactification. Stone-Cech compactification.	11	4
V	Compactness in metric spaces. Equivalence of compactness, countable compactness and sequential compactness in metric space. Connected spaces. Connectedness on the real line. Components. Locally connected spaces.	11	5

Books Recommended:

1. James R. Munkres, *Topology,* (2nd Edition) Pearson Education, New Delhi, 2021.
2. K. D. Joshi, *Introduction to General Topology*, (3rd Edition), New Age International Pvt. Ltd., India, 2022.

Reference Books:

1. J. Dugundji, *Topology*, Allyn and Bacon, Prentice Hall of India Pvt. Ltd., India, 1966.
2. G. F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw Hill Education, 2017.
3. J. Hocking, G. Young *Topology*, New Edition, Dover Publications Inc, 1988.
4. J. L. Kelley, *General Topology*, Reprint Edition, Dover Publications Inc., 2017.
5. L. Steen, J.A. Jr. Seebach, *Counterexamples in Topology*, , Second Edition, Springer, 1978.
6. W. Thron, *Topologically Structures*, Holt, Rinehart and Winston, New York,1966.
7. N. Bourbaki, *General Topology,* Springer, 1998.

8. R. Engelking, *General Topology*, Heldermann Verlag, 1989.
9. W. J. Pervin, *Foundations of General Topology*, Academic Press Inc. 2014.
10. E. H. Spanier, *Algebraic Topology*, McGraw-Hill, New York,1966.
11. S. Willard, *General Topology*, Dover, 2004.
12. Crump W. Baker, *Introduction to Topology*, Krieger Publishing Company, 1996.
13. Sze-Tsen Hu, *Elements of General Topology*, Vakils, Feffer and Simons Pvt. Ltd., 1972.
14. D. Bushaw, *Elements of General Topology*, First Edition John Wiley & Sons, New York, 1963.
15. M. J. Mansfield, *Introduction to Topology*, Princeton, N.J. : Van Nostrand, 1963.
16. B. Mendelson, *Introduction to Topology*, Allyn & Bacon, Inc., Boston,1962.
17. C. Berge, *Topological Spaces*, Macmillan Company, New York,1963.
18. S. S. Coirns, *Introductory Topology*, Ronald Press, New York, 1968.
19. Z. P. Mamuzic, *Introduction to General Topology*, P. Noordhoff Ltd.,Groningen, 1963.

M.Sc. (Mathematics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	I
Course Code	Course Title		Course Type
MAT140	**ADVANCED COMPLEX ANALYSIS (I)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

This course aims to impart students with a profound comprehension of complex analysis, about the topics such as complex integration, key theorems, residues, bilinear transformations, and mapping theorems. Through this knowledge, they will develop a strong foundation in both the theory and practical applications of complex analysis.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Evaluate complex integration using Cauchy-Goursat Theorem, Cauchy's Integral Formula and Taylor's theorem. Explain Fundamental Theorem of Algebra, Morera's Theorem. Apply Cauchy's Inequality, Liouville's Theorem. Solve problems related to isolated singularities and meromorphic functions.	An
2	Explain and apply the Maximum Modulus Principle, Schwarz Lemma, Argument Principle, Rouche's Theorem, and Inverse Function Theorem, to solve complex mathematical problems.	Ap
3	Explain residues, apply Cauchy's Residue Theorem to evaluate complex integrals. Describe branches of many-valued functions, with a special focus on arg z, log z, and z^a.	U
4	Explain bilinear transformations, and its properties. Classify according to their behavior on the complex plane. Explain various types of conformal mappings.	U
5	Explore analytic function spaces, their properties and applications. Apply Hurwitz's, Montel's and Riemann mapping theorems, to handle different problems.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	3
CO2	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	3
CO3	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	3
CO4	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	3
CO5	3	3	3	2	2	1	2	1	-	2	2	3	1	2	-	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Complex integration, Cauchy-Goursat. Theorem. Cauchy's integral formula. Higher order derivatives. Morera's Theorem. Cauchy's inequality and Liouville's theorem. The fundamental theorem of algebra. Taylor's theorem. Laurent's series. Isolated singularities. Meromorphic functions.	19	1
II	Maximum modulus principle. Schwarz lemma. The argument principle. Rouche's theorem, Inverse function theorem.	12	2
III	Residues. Cauchy's residue theorem. Evaluation of integrals. Branches of many valued functions with special reference to arg z, logz and z^a.	12	3
IV	Bilinear transformations, their properties and classifications. Definitions and examples of Conformal mappings.	14	4
V	Spaces of analytic functions. Hurwitz's theorem. Montel's theorem Riemann mapping theorem.	18	5

Books Recommended:

1. L.V.Ahlfors, *Complex Analysis*, McGraw - Hill, 1979.
2. J.B. Conway, *Functions of one Complex variable*, Narosa Publishing House,1980.

Reference Books:

1. H.A. Priestly, *Introduction to Complex Analysis*, Clarendon Press, Oxford, 1990.
2. D.Sarason, Complex Function Theory, (2nd Edition) American Mathematical Society, 2007.
3. Liang-shin Hahn & Bernard Epstein, *Classical Complex Analysis*, Jones and Bartlett Publishers International, London, 1996.
4. S. Lang, *Complex Analysis*, Addison Wesley, 1977.
5. Mark J.Ablowitz and A.S. Fokas, *Complex Variables: Introduction and Applications*, Cambridge University press, South Asian Edition, 1998.
6. E. Hille, *Analytic Function Theory* (2 Vols.) Gonn & Co., 1959.
7. W.H.J. Fuchs, *Topics in the Theory of Functions of one Complex Variable*, D.Van Nostrand Co., 1967.
8. C.Caratheodory, *Theory of Functions (2 Vols.)* Chelsea Publishing Company, 1964.
9. M.Heins, *Complex Function Theory*, Academic Press, 1968.
10. Walter Rudin, *Real and Complex Analysis*, McGraw-Hill Book Co., 1966.
11. S.Saks and A.Zygmund, *Analytic Functions*, Monografic Matematyczne, 1952.
12. E.C Titchmarsh, *The Theory of Functions*, Oxford University Press, London, 1939.
13. W.A. Veech, *A Second Course in Complex Analysis*, W.A. Benjamin, 1967.
14. S.Ponnusamy, *Foundations of Complex Analysis*, Narosa Publishing House, 1997.

M.Sc. (Mathematics) Semester-I

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	I
Course Code	Course Title		Course Type
MAT150	**ADVANCED DISCRETE MATHEMATICS (I)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
4	4	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The objective of this course is to develop a profound comprehension of advanced topics in discrete mathematics. These topics encompass formal logic, algebraic structures, lattice theory, Boolean algebra, grammars, and languages. Students will acquire proficiency in the theory and practical applications of discrete mathematics at an advanced level.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Describe formal logic, including symbolic representation, tautologies. Apply quantifiers, predicates, and propositional logic. Evaluate the validity of logical arguments. Explain concepts of semigroups and monoids, including concatenation operations.	**U**
2	Analyze homomorphisms on semigroups and monoids, apply congruence relations, construct quotient semigroups. Describe direct products in semigroups and monoids.	**An**
3	Express lattices as partially ordered sets and its properties. Apply concepts of sublattices, direct products, and homomorphisms. Explain complete, complemented, and distributive lattices. Apply Boolean algebra properties in various contexts.	**Ap**
4	Express Boolean Forms as direct products, homomorphisms, minterms, maxterms and their equivalence. Apply Boolean algebra principles to switching theory and Karnaugh map method for minimization.	**Ap**
5	Analyze phrase-structure grammars, rewriting rules, derivations, and sentential forms. Examine languages generated by grammars. Distinguish regular, context-free, and context-sensitive grammars and languages. Convert infix expressions to Polish notations and reverse Polish notations.	**An**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	1	2	-	-	2	2	3	1	1	-	-
CO2	3	3	3	2	2	1	2	-	-	2	2	3	1	1	-	-
CO3	3	3	3	2	2	1	2	-	-	2	2	3	1	1	-	-
CO4	3	3	3	2	2	1	2	-	-	2	2	3	1	1	-	-
CO5	3	3	3	1	2	1	2	-	-	2	2	3	1	1	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Formal Logic-Statements. Symbolic Representation and Tautologies. Quantifiers, Predicates and Validity. Propositional Logic. Semigroups & Monoids-Definitions and Examples of Semigroups and monoids (including those pertaining to concatenation operation).	11	1
II	Homomorphism of semigroups and monoids. Congruence relation and Quotient Semigroups. Subsemigroup and submonoids. Direct Products. Basic Homomorphism Theorem.	12	2
III	Lattices-Lattices as partially ordered sets. Their properties. Lattices as Algebraic Systems. Sublattices, Direct products, and Homomorphisms. Some Special Lattices e.g., Complete, Complemented and Distributive Lattices. Boolean Algebras-Boolean Algebras as Lattices. Various Boolean Identities. The Switching Algebra example. Subalgebras.	13	3
IV	Direct Products and Homomorphisms. Join-Irreducible elements, Atoms and Minterms. Boolean Forms and Their Equivalence. Minterm Boolean Forms, Sum of Products Canonical Forms. Minimization of Boolean Functions. Applications of Boolean Algebra to Switching Theory (using AND,OR & NOT gates). The Karnaugh Map Method.	13	4
V	Grammars and Languages-Phrase-Structure Grammars. Rewriting Rules. Derivations. Sentential Forms. Language generated by a Grammar. Regular, Context-Free, and Context Sensitive Grammars and Languages. Regular sets, Regular Expressions. Notions of Syntax Analysis, Polish Notations. Conversion of Infix Expressions to Polish Notations. The Reverse Polish Notation.	11	5

Books Recommended:

1. C.l.Liu, *Elements of Discrete Mathematics,* McGraw Hill Education India, 1986
2. J.P. Tremblay & R. Manohar, *Discrete Mathematical Structures with Applications to Computer Science,* McGraw-Hill Book Co., 1997.

Reference Books:

1. J.L. Gersting, *Mathematical Structures for Computer Science*, W.H.Freeman and Company, 2003.
2. Seymour Lepschutz, *Finite Mathematics*, McGraw-Hill Book Company, 1983.

3. S.Wiitala*, Discrete Mathematics-A Unified Approach*, McGraw-Hill Book Co., 1987
4. J.E. Hopcroft and J.D Ullman, *Introduction to Automata Theory, Languages & Computation*, Narosa Publishing House, 2001
5. N. Deo, *Graph Theory with Application to Engineering and Computer Sciences*, Prentice Hall of India, 1979
6. K.L.P.Mishra and N.Chandrashekaran, *Theory of Computer Science,* Prentice Hall of India, 2002.

M.Sc. (Mathematics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	II
Course Code	Course Title		Course Type
MAT210	**ADVANCED ABSTRACT ALGEBRA (II)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The aim of this course is to equip students with a deep understanding of abstract algebra concepts, particularly in modules, linear transformations, canonical forms, and their applications across various mathematical contexts. Make them proficient in applying these concepts to solve complex problems and analyze mathematical structures.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Illustrare cyclic, simple, semi-simple, and free modules. State and prove properties and theorems of Noetherian and Artinian modules and rings, including the Hilbert Basis Theorem and the Wedderburn-Artin Theorem. Discuss significance of uniform and primary modules.	U
2	Describe algebraic properties of linear transformations, calculate characteristic roots. Relate matrices and linear transformations. Solve problems involving linear transformations and matrices.	U
3	Explain similarity of linear transformations, invariant subspaces. Perform reduction to triangular forms. Illustrate properties of nilpotent transformations. Apply the primary decomposition theorem.	Ap
4	Apply the principles of Smith normal form over a PID and the rank of matrices and modules. Utilize the fundamental structure theorem for finitely generated modules over a PID, to deduce structure or finitely generated abelian groups. Analyze and decompose matrices and modules.	An
5	Evaluate and apply rational canonical form and generalized Jordan form over any field. Analyze linear transformations, matrices, and modules to determine their canonical forms.	E

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	1	2	-	-	3	3	3	3	2	-	-
CO2	3	3	3	1	2	1	2	-	-	3	3	3	3	2	-	3
CO3	3	3	3	1	2	1	2	-	-	3	3	3	3	2	-	2
CO4	3	3	3	1	2	1	2	-	-	3	3	3	3	2	-	-
CO5	3	3	3	1	2	1	2	-	-	3	2	3	3	2	-	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Modules - Cyclic modules. Simple modules. Semi-simple modules. Schuler's Lemma. Free modules. Noetherian and artinian modules and rings-Hilbert basis theorem. Wedderburn Artin theorem. Uniform modules, primary modules, and Noether-Lasker theorem.	17	1
II	Linear Transformations - Algebra of linear transformation, characteristic roots, matrices and linear transformations.	13	2
III	Canonical Forms - Similarity of linear transformations. Invariant subspaces. Reduction to triangular forms. Nilpotent transformations. Index of nilpotency. Invariants of a nilpotent transformation. The primary decomposition theorem. Jordan blocks and Jordan forms.	17	3
IV	Smith normal form over a principal ideal domain and rank. Fundamental structure theorem for finitely generated modules over a Principal ideal domain and its applications to finitely generated abelian groups.	16	4
V	Rational canonical from. Generalised Jordan form over any field.	12	5

Books Recommended:

1. P.B.Bhattacharya, S.K.Jain, S.R.Nagpaul, *Basic Abstract Algebra*, Cambridge University press, 1994
2. I.N.Herstein, *Topics in Algebra*, Wiley Eastern Ltd., 1999
3. Quazi Zameeruddin, Surjeet Singh, *Modern Algebra*, Vikas Publishing House Pvt. Ltd., 1990

Reference Books:

1. M.Artin, *Algebra*, Prentice -Hall of India, 1991.
2. P.M. Cohn, *Algebra*,Vols. I,II &III, John Wiley & Sons, 1982,1989,1991.
3. N.Jacobson, *Basic Algebra*, Vols. I , W.H. Freeman, 1980
4. S.Lang, *Algebra*, 3rd edition, Addison-Wesley, 1993.
5. I.S. Luther, I.B.S. Passi, *Algebra*, Vol. I-Groups, Vol.II-Rings, Narosa Publishing House (Vol.I-1996,Vol. II-1999)
6. D.S.Malik, J.N.Mordeson, M.K.Sen, *Fundamentals of Abstract Algebra*, Mc Graw-Hill, International Edition,1997.
7. Vivek Sahai and Vikas Bist, *Algebra*, Narosa Publishing House, 1999.
8. I. Stewart, *Galois theory*, Chapman and Hall, 1989.
9. J.P. Escofier, *Galois theory*, GTM Vol.204, Springer, 2001.
10. J.B.Fraleigh, *A first course in Algebra*, Narosa,1982.

M.Sc. (Mathematics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	II
Course Code	Course Title		Course Type
MAT220	**REAL ANALYSIS (II)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The aim of this course to provide students a deep understanding of advanced topics in real analysis, particularly focusing on integration theory (Riemann-Stieltjes and Lebesgue), measure theory, differentiation theorems, and Lp-spaces. Make then capable to apply these concepts to solve complex mathematical problems and gain a solid foundation in modern real analysis.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain Riemann-Stieltjes integral, its properties and applications. Apply fundamental theorem of calculus, to connect integration and differentiation in real-valued and vector-valued functions. Analyze uniform convergence and its implications in Riemann-Stieltjes integration. Explore rectifiable curves.	**Ap**
2	Describe Lebesgue outer measure and its properties. Analyze measurable functions, explain concepts of Borel and Lebesgue measurability, including non-measurable sets. Integrate non-negative functions and series.	**U**
3	Explain measures and outer measures, their properties and applications. Describe extension of a measure, the uniqueness of extension and completion of a measure. Apply integration with respect to a measure, including Riemann and Lebesgue integrals.	**Ap**
4	Analyze the four derivatives, apply Lebesgue Differentiation Theorem, explore its implications in connecting differentiation and integration. Explain functions of bounded variation, their properties and applications.	**An**
5	Explore L^p -spaces, their properties and applications. Apply Jensen's, Holder and Minkowski inequalities to handle inequalities involving integrals and norms.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	2	2	1	2	1	-	2	2	3	1	2	-	1
CO2	3	3	2	2	2	1	2	1	-	2	2	3	1	2	-	-
CO3	3	3	2	2	2	1	2	1	-	2	2	3	1	2	-	-
CO4	3	3	2	2	2	1	2	1	-	2	2	3	1	2	-	-
CO5	3	3	2	1	2	1	2	1	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Definition and existence of Riemann-Stieltjes integral, Properties of the Integral, integration and differentiation, the fundamental theorem of Calculus, integration of vector-valued functions, Uniform convergence and Riemann-Stieltjes integration, Rectifiable curves.	12	1
II	Lebesgue outer measure. Measurable sets. Regularity. Measurable functions. Boral and Lebesgue measurability. Non-measurable sets. Integration of Non-negative functions. The General integral. Integration of Series.	18	2
III	Measures and outer measures, Extension of a measure. Uniqueness of Extension. Completion of a measure. Measure spaces. Integration with respect to a measure. Reimann and Lebesgue Integrals.	15	3
IV	The Four derivatives. Lebesgue Differentiation Theorem. Differentiation and Integration. Functions of Bounded variation.	14	4
V	The Lp-spaces. Convex functions. Jensen's inequality. Holder and Minkowski inequalities. Completeness of Lp, Convergence in Measure, Almost uniform convergence.	16	5

Books Recommended:

1. Walter Rudin, *Principle of Mathematical Analysis*, (3rd Edition) McGraw-Hill, Kogakusha, 1976.
2. H.L.Roydon, Real *Analysis*, Macmillan Pub.Co.Inc. (4th Edition), New York .1962.

Reference Books:

1. T.M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi,1985.
2. G. Klambauer, *Mathematical Analysis*, Marcel Dekkar,Inc. New York,1975.
3. A.J. White, *Real Analysis*: *an introduction*, Addison-Wesley Publishing Co., Inc.,1968.
4. G.de Barra, *Measure Theory and Integration*, Wiley Eastern Limited, 1981.
5. E. Hewitt and K. Stromberg, *Real and Abstract Analysis*, Berlin, Springer, 1969.
6. P.K. Jain and V.P. Gupta, *Lebesgue Measure and Integration*, New Age International Pvt. Ltd., New Delhi, 1986.
7. I.P. Natanson, *Theory of Functions of a Real Variable*. Vol. 1, Frederick Ungar Publishing Co., 1961.

8. R.L. Wheeden and A. Zygmund, *Measure and Integral: An Introduction to Real Analysis*, Marcel Dekker Inc.1977.
9. J.H. Williamson, *Lebesgue Integration*, Holt Rinehart and Winston, Inc. New York. 1962.
10. A. Friedman, *Foundations of Modern Analysis*, Holt, Rinehart and Winston, Inc., New York, 1970.
11. P.R. Halmos, *Measure Theory*, Van Nostrand, Princeton, 1950.
12. T.G. Hawkins, *Lebesgue's Theory, of Integration: Its Origins and Development*, Chelsea, New York, 1979.
13. K.R. Parthasarathy, *Introduction to Probability and Measure*, Macmillan Company of India Ltd., Delhi, 1977.
14. R.G. Bartle, *The Elements of Integration*, John Wiley & Sons, Inc. New York, 1966.
15. Serge Lang, *Analysis I & II*, Addison-Wesley Publishing Company, Inc. 1969.
16. Inder K. Rana, *An Introduction to Measure and Integration*, Norosa Publishing House, Delhi, 1997.
17. Walter Rudin, *Real & Complex Analysis*, Tata McGraw-Hill Publishing Co.Ltd. New Delhi, 1966.

M.Sc. (Mathematics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	II
Course Code	Course Title		Course Type
MAT230	**GENERAL AND ALBEGRAIC TOPOLOGY**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--
Maximum Marks	CIA	ESE	
100	30	70	

Learning Objective (LO):

The course aims to equip students with a profound grasp of advanced topics in topology, encompassing product spaces, embedding and metrization theorems, nets and filters, and fundamental group theory. This knowledge will empower them to establish a strong foundation in both algebraic and point-set topology.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Describe projection maps. Explain Tychonoff product topology, construct it in terms of standard sub-bases. Relate Separation axioms and product spaces.	**Ap**
2	Describe connectedness and compactness in product spaces. Explain Tychonoff's theorem. Analyze countability in product spaces.	**An**
3	Describe embedding lemma, Tychonoff embedding, and Urysohn metrization theorem. Explain metrization theorems and their relationship with Paracompactness and Local finiteness, Nagata-Smirnov metrization theorem. Explain Smirnov metrization theorem.	**U**
4	Explain Nets, Filters and their convergence. Relate Hausdorffness, Compactness, and Nets. Apply canonical methods to transform nets into filters and vice versa. Explain ultra-filters in compact sets.	**Ap**
5	Describe Homotopy of paths, the Fundamental Group, and Covering Spaces. Explain fundamental group of the circle and its relevance to the fundamental theorem of algebra.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	-
CO2	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	-
CO3	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	-
CO4	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	-
CO5	3	3	3	1	2	-	2	1	-	2	2	3	-	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Tychonoff product topology in terms of standard sub-base and its characterizations. Projection maps. Separation axioms and product spaces.	14	1
II	Product spaces. Connectedness and product spaces. Compactness and product spaces (Tychonoff's theorem). Countability and product spaces.	18	2
III	Embedding and metrization. Embedding lemma and Tychonoff embedding. The Urysohn metrization theorem. Metrization theorems and Paracompactness-Local finiteness. The Nagata-Smirnov metrization theorem. Paracompactness. The Smirnov metrization theorem.	13	3
IV	Nets and filter. Topology and convergence of nets. Hausdorffness and nets. Compactness and nets. Filters and their convergence. Canonical way of converting nets to filters and vice-versa. Ultra-filters and Compactness.	15	4
V	The fundamental group and covering spaces-Homotopy of paths. The fundamental group. Covering spaces. The fundamental group of the circle and the fundamental theorem of algebra.	15	5

Books Recommended:

1. James R. Munkres, *Topology,* (2nd Edition) Pearson Education, New Delhi, 2021.
2. K. D. Joshi, *Introduction to General Topology*, (3rd Edition), New Age International Pvt. Ltd., India, 2022.

Reference Books:

1. J. Dugundji, *Topology*, Allyn and Bacon, Prentice Hall of India Pvt. Ltd., India, 1966.
2. G. F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw Hill Education, 2017.
3. J. Hocking, G. Young *Topology*, New Edition, Dover Publications Inc, 1988.
4. J. L. Kelley, *General Topology*, Reprint Edition, Dover Publications Inc., 2017.
5. L. Steen, J.A. Jr. Seebach, *Counterexamples in Topology*, , Second Edition, Springer, 1978.
6. W. Thron, *Topologically Structures*, Holt, Rinehart and Winston, New York,1966.
7. N. Bourbaki, *General Topology,* Springer, 1998.
8. R. Engelking, *General Topology*, Heldermann Verlag, 1989.
9. W. J. Pervin, *Foundations of General Topology*, Academic Press Inc. 2014.
10. E. H. Spanier, *Algebraic Topology*, McGraw-Hill, New York,1966.
11. S. Willard, *General Topology*, Dover, 2004.

12. Crump W. Baker, *Introduction to Topology*, Krieger Publishing Company, 1996.
13. Sze-Tsen Hu, *Elements of General Topology*, Vakils, Feffer and Simons Pvt. Ltd., 1972.
14. D. Bushaw, *Elements of General Topology*, First Edition John Wiley & Sons, New York, 1963.
15. M. J. Mansfield, *Introduction to Topology*, Princeton, N.J. : Van Nostrand, 1963.
16. B. Mendelson, *Introduction to Topology*, Allyn & Bacon, Inc., Boston,1962.
17. C. Berge, *Topological Spaces*, Macmillan Company, New York,1963.
18. S. S. Coirns, *Introductory Topology*, Ronald Press, New York, 1968.
19. Z. P. Mamuzic, *Introduction to General Topology*, P. Noordhoff Ltd.,Groningen, 1963.

M.Sc. (Mathematics) Semester-II

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	II
Course Code	Course Title		Course Type
MAT240	**ADVANCED COMPLEX ANALYSIS (II)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

This course aims to cultivate a profound comprehension of advanced topics in complex analysis, encompassing special functions, theorems related to analytic continuation, harmonic functions, and univalent functions. By the end of this course, students will possess the ability to effectively apply these concepts.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explore meromorphic functions and Weierstrass' factorization theorem. Explain Gamma function, its properties. Analyze the Riemann Zeta function and the Riemann functional equation. Apply Runge's theorem and Mittag-Leffler's theorem.	**Ap**
2	Describe analytic continuation and its uniqueness. Explore power series for analytic continuation and apply Schwarz Reflection Principle. Analyze the Monodromy theorem and its consequences.	**U**
3	Explain harmonic functions. Apply Harnack's inequality and theorem to harmonic functions. Describe Dirichlet Problem and solve boundary value problems. Explain Green's function and its applications.	**Ap**
4	Explain canonical products, their properties. Apply Jensen's formula and the Poisson-Jensen formula, to analyze the distribution of zeros of entire functions. Apply Hadamard's Three Circles Theorem to entire functions. Describe Borel's theorem and Hadamard's factorization theorem.	**An**
5	Describe the range of analytic functions, apply the theorems of Bloch, Little Picard, Schottky, Montel, Caratheodory, and the Great Picard Theorem. Explain univalent functions, their properties. State Bieberbach's Conjecture and the 1/4-theorem.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	1	2	2	1	2	1	-	2	2	3	1	2	-	-
CO2	3	3	1	2	2	1	2	1	-	2	2	3	1	2	-	-
CO3	3	3	1	2	2	1	2	1	-	2	2	3	1	2	-	-
CO4	3	3	1	2	2	1	2	1	-	2	2	3	1	2	-	-
CO5	3	3	1	2	2	1	2	1	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Weierstrass' factorisation theorem. Gamma function and its properties. Riemann Zeta function. Riemann's functional equation. Runge's theorem. Mittag-Leffler's theorem.	18	1
II	Analytic Continuation. Uniqueness of direct analytic continuation. Uniqueness of analytic continuation along a curve. Power series method of analytic continuation Schwarz Reflection Principle. Monodromy theorem and its consequences.	13	2
III	Harmonic functions on a disk. Harnack's inequality and theorem. Dirichlet Problem. Green's function.	16	3
IV	Canonical products. Jensen's formula. Poisson-Jensen formula. Hadamard's three circles theorem. Order of an entire function. Exponent of Convergence. Borel's theorem. Hadamard's factorization theorem.	13	4
V	The range of an analytic function. Bloch's theorem. The Little Picard theorem. Schottky's theorem. Montel Caratheodory and the Great picard theorem. Univalent functions. Bieberbach's conjecture (Statement only) and the 1/4-theorem.	15	5

Books Recommended:

1. L.V.Ahlfors, *Complex Analysis*, McGraw - Hill, 1979.
2. J.B. Conway, *Functions of one Complex variable*, Narosa Publishing House,1980.

Reference Books:

1. H.A. Priestly, *Introduction to Complex Analysis*, Clarendon Press, Oxford, 1990.
2. D.Sarason, Complex Function Theory, (2nd Edition) American Mathematical Society, 2007.
3. Liang-shin Hahn & Bernard Epstein, *Classical Complex Analysis*, Jones and Bartlett Publishers International, London, 1996.
4. S. Lang, *Complex Analysis*, Addison Wesley, 1977.
5. Mark J.Ablowitz and A.S. Fokas, *Complex Variables: Introduction and Applications*, Cambridge University press, South Asian Edition, 1998.
6. E. Hille, *Analytic Function Theory* (2 Vols.) Gonn & Co., 1959.
7. W.H.J. Fuchs, *Topics in the Theory of Functions of one Complex Variable*, D.Van Nostrand Co., 1967.
8. C.Caratheodory, *Theory of Functions (2 Vols.)* Chelsea Publishing Company, 1964.
9. M.Heins, *Complex Function Theory*, Academic Press, 1968.
10. Walter Rudin, *Real and Complex Analysis*, McGraw-Hill Book Co., 1966.
11. S.Saks and A.Zygmund, *Analytic Functions*, Monografic Matematyczne, 1952.

12. E.C Titchmarsh, *The Theory of Functions*, Oxford University Press, London, 1939.
13. W.A. Veech, *A Second Course in Complex Analysis*, W.A. Benjamin, 1967.
14. S.Ponnusamy, *Foundations of Complex Analysis*, Narosa Publishing House, 19

M.Sc. (Mathematics) Semester-II

Program	Subject		Year	Semester
M.Sc.	Mathematics		1	II
Course Code	Course Title			Course Type
MAT250	**ADVANCED DISCRETE MATHEMATICS (II)**			Core
Credit	Hours Per Week (L-T-P)			
	L		T	P
4	4		1	--
Maximum Marks	CIA		ESE	
100	30		70	

Learning Objective (LO):

The objective of this course is to equip students with a solid grasp of graph theory principles, algorithms, and introductory concepts in computability theory. Students will gain the ability to apply these concepts for graph analysis, problem-solving, and attaining insights into computational processes and language recognition.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain undirected graphs, paths, circuits, cycles, and subgraphs. Calculate the degree of a vertex. Illustrate properties of planar graphs. Explain tree structures and Euler's formula for connected planar graphs. State and apply Kuratowski's Theorem.	**U**
2	Describe spanning trees, cut-sets, fundamental cut-sets, and cycles. Use Kruskal's Algorithm to find minimal spanning trees. Explain matrix representations of graphs. Apply Euler's Theorem on the existence of Eulerian paths and circuits.	**Ap**
3	Explain graphs, in-degree and out-degree of a vertex, their properties and applications. Describe weighted undirected graphs and apply Dijkstra's Algorithm to find shortest paths. Apply Warshall's Algorithm.	**AP**
4	Analyze finite state machines and construct transition table diagrams, illustrate their operation and equivalence. Apply homomorphism principles to finite state machines.	**An**
5	Explain finite automata and acceptors. Distinguish non-deterministic and deterministic finite automata and describe their equivalence. Explain Moore, Mealy and Turing machines. Apply Pumping Lemma and Kleene's Theorem to solve problem related to languages and automata.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	2	1	2	-	-	3	2	3	1	1	-	-
CO2	3	3	3	2	2	1	2	-	-	3	2	3	1	1	-	-
CO3	3	3	3	2	2	1	2	-	-	3	2	3	1	1	-	-
CO4	3	3	3	2	2	1	2	-	-	3	2	3	1	1	-	-
CO5	3	3	3	1	2	1	2	-	-	3	2	3	1	1	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Graph Theory-Definition of (Undirected) Graphs, Paths, Circuits, Cycles, & Subgraphs. Induced Subgraphs. Degree of a vertex. Connectivity. Planar Graphs and their properties. Trees. Euler's Formula for connected planar Graphs. Complete & Complete Bipartite Graphs. Kuratowski's Theorem(statement only) and its use.	12	1
II	Spanning Trees, Cut-sets, Fundamental Cut -sets, and Cycle. Minimal Spanning Trees and Kruskal's Algorithm. Matrix Representations of Graphs. Euler's Theorem on the Existence of Eulerian Paths and Circuits.	12	2
III	Graphs. In degree and Out degree of a Vertex. Weighted undirected Graphs. Dijkstra's Algorithm, strong Connectivity & Warshall's Algorithm. Directed Trees. Search Trees. Tree Traversals.	12	3
IV	Introductory Computability Theory-Finite State Machines and their Transition Table Diagrams. Equivalence of finite State Machines. Reduced Machines. Homomorphism.	12	4
V	Finite Automata. Acceptors. Non-deterministic Finite Automata and equivalence of its power to that of Deterministic Finite Automata. Moore and mealy Machines. Turing Machine and Partial Recursive Functions. The Pumping Lemma. Kleene's Theorem.	12	5

Books Recommended:

1. C.l.Liu, *Elements of Discrete Mathematics,* McGraw Hill Education India, 1986
2. J.P. Tremblay & R. Manohar, *Discrete Mathematical Structures with Applications to Computer Science,* McGraw-Hill Book Co., 1997.

Reference Books:

1. J.L. Gersting, *Mathematical Structures for Computer Science*, W.H.Freeman and Company, 2003.
2. Seymour Lepschutz, *Finite Mathematics*, McGraw-Hill Book Company, 1983.
3. S.Wiitala, *Discrete Mathematics-A Unified Approach*, McGraw-Hill Book Co., 1987
4. J.E. Hopcroft and J.D Ullman, *Introduction to Automata Theory, Languages & Computation*, Narosa Publishing House, 2001
5. N. Deo, *Graph Theory with Application to Engineering and Computer Sciences*, Prentice Hall of India, 1979
6. K.L.P.Mishra and N.Chandrashekaran, *Theory of Computer Science,* Prentice Hall of India, 2002.

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT310	**INTEGRATION THEORY AND FUNCTIONAL ANALYSIS (I)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The objective of this course is to cultivate a profound comprehension of advanced concepts in integration theory and functional analysis. By the end of this course, students will possess the knowledge and skills required to analyze measures, conduct integrations, and manipulate normed linear spaces, Banach spaces, and their dual spaces effectively.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Analyze and apply advanced mathematical concepts, including signed measures, the Hahn decomposition theorem, mutually singular measures, the Radon-Nikodym theorem, Lebesgue decomposition, Riesz representation theorem, and the Caratheodory extension theorem.	**Ap**
2	Explain Lebesgue-Stieltjes integral, product measures, and Fubini's theorem. Differentiate and integrate functions, as well as decompose measures into their absolutely continuous and singular components.	**U**
3	Describe the concepts of Baire sets and Baire measure. Apply their knowledge to continuous functions with compact support. Explain regularity of measures on locally compact spaces. Integrate continuous functions with compact support and apply the Riesz-Markoff theorem.	**Ap**
4	Express normed linear spaces, including Banach spaces and relevant examples. Express concept of quotient spaces within normed linear spaces, their completeness and equivalency in terms of norms. Apply the Riesz Lemma, describe finite-dimensional normed linear spaces.	**U**
5	Explain weak convergence and its implications, particularly in the context of bounded linear transformations. Work with normed linear spaces of bounded linear transformations. Express dual spaces with examples.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	1	2	-	2	1	-	2	1	3	1	2	-	-
CO2	3	3	3	2	2	-	2	1	-	2	1	3	1	2	-	-
CO3	3	3	3	2	2	1	2	1	-	3	1	3	1	2	-	-
CO4	3	3	3	2	2	1	2	1	-	3	1	3	1	2	-	-
CO5	3	3	3	1	2	1	2	1	-	3	1	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Signed measure. Hahn decomposition theorem, mutually singular measures. Radon-Nikodym theorem. Labesgue decomposition. Riesz representation theorem. Extension theorem (Caratheodory).	17	1
II	Lebesgue-Stieltjes integral, product measures, Fubini's theorem. Differentiation and Integration. Decomposition into absolutely continuous and singular parts.	17	2
III	Baire sets. Baire measure, continuous functions with compact support. Regularity of measures on locally compact spaces. Integration of continuous functions with compact support, Riesz-Markoff theorem.	17	3
IV	Normed linear spaces. Banach spaces and examples. Quotient space of normed linear spaces and its completeness, equivalent norms. Riesz Lemma, basic properties of finite dimensional normed linear spaces and compactness.	12	4
V	Weak convergence and bounded linear transformations, normed linear spaces of bounded linear transformations, dual spaces with examples.	12	5

Books Recommended:

1. P.R. Halmos, *Measure Theory*, Van Nostrand, Princeton, 1950.
2. B.Choudhary and S.Nanda, *Functional Analysis with Applications*, Wiley Eastern Ltd. 1989.
3. H.L. Royden, *Real Analysis*, Macmillan Publishing Co. Inc., New York, 1993.

Reference Books:

1. S.K. Berberian, *Measure and integration*, Chelsea Publishing Company, New York, 1965.
2. G. de Barra, *Measure Theory and Integration*, Wiley Eastern Limited, 1981.
3. P.K. Jain and V.P. Gupta, *Lebesgue Measure and Integration*, New Age International Pvt. Ltd., New Delhi, 2000.
4. Richard L. Wheeden and Antoni Zygmund, *Measure and Integral : An Introduction to Real Analysis*, Marcel Dekker Inc. 1977.
5. J.H. Williamson, *Lebesgue Integration*, Holt Rinehart and Winston, Inc. New York. 1962.
6. T.G. Hawkins, *Lebesgue's Theory of Integration: Its Origins and Development*, Chelsea, New York, 1979.
7. K.R. Parthasarathy, *Introduction to Probability and Measure*, Macmillan Company of India Ltd., Delhi, 1977.
8. R.G. Bartle, *The Elements of Integration*, John Wiley & Sons, Inc. New York, 1966.
9. Serge Lang, *Analysis I & II*, Addison-Wesley Publishing Company, Inc. 1967.

10. Inder K. Rana, *An Introduction to Measure and Integration*, Narosa Publishing House, Delhi, 1997.
11. Walter Rudin, *Real & Complex Analysis*, Tata McGraw-Hill Publishing Co.Ltd. New Delhi, 1966.
12. Edwin Hewitt and Kenneth A. Ross, *Abstract Harmonic Analysis*, Vol. 1, Springer-Verlag, 1993.
13. G. Bachman and L. Narici, *Functional Analysis*, Academic Press, 1966.
14. N. Dunford and J.T. Schwartz, *Linear Operators, Part* I, Interscience, New York, 1958.
15. R.E. Edwards, *Functional Analysis*, Holt Rinehart and Winston, New York, 1965.
16. C. Goffman and G. Pedrick, *First Course in Functional Analysis*, Prentice Hall of India, New Delhi, 1987.
17. P.K. Jain, O.P. Ahuja and Khalil Ahmad, *Functional Analysis*, New Age International (P) Ltd. & Wiley Eastern Ltd., New Delhi, 1997.
18. R.B. Holmes, *Geometric Functional Analysis and its Applications*, Springer-Verlag, 1975.
19. K.K. Jha, *Functional Analysis*, Students' Friends, 1986.
20. L.V. Kantorovich and G.P. Akilov, *Functional Analysis*, Pergamon Press, 1982.
21. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley & Sons, New York, 1978.
22. B.K. Lahiri, *Elements of Functional Analysis*, The World Press Pvt. Ltd., Calcutta, 1994.
23. A.H.Siddiqui, *Functional Analysis with Applications*, Tata McGraw-Hill Publishing Company Ltd. New Delhi
24. B.V. Limaye, *Functional Analysis*, Wiley Eastern Ltd.
25. L.A. Lustenik and V.J. Sobolev, *Elements of Functional Analysis*, Hindustan Publishing Corporation, New Delhi, 1971.
26. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill Book Company, New York, 1963.
27. A.E. Taylor*, Introduction to Functional Analysis*, John Wiley and Sons, New York, 1958.
28. K.Yosida, *Functional Analysis*, Springer-Verlag, New York, 1971.
29. J.B. Conway, *A Course in Functional Analysis*, Springer-Verlag, New York, 1990.
30. Walter Rudin, *Functional Analysis*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1973.
31. A. Wilansky, *Functional Analysis*, Blaisdell Publishing Co., 1964.
32. J. Tinsley Oden & Leszek F. Dernkowicz, *Applied Functional Analysis*, CRC Press Inc., 1996.

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT320	**PARTIAL DIFFERENTIAL EQUATIONS & MECHANICS (I)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The aim of this course is to develop profound understanding of advanced topics in partial differential equations and classical mechanics among students, equipping them with the knowledge and skills necessary to analyze and solve complex problems in these fields, including variational problems and gravitational attraction in various geometries.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Classify PDEs. Solve transport equations via initial value problems and non-homogeneous equations. Describe Laplace's equation, its fundamental solutions, mean value formulas, properties of harmonic functions, and Green's functions.	**U**
2	Determine fundamental solutions, mean value formulas of heat equation. Apply energy methods to tackle heat equation problems. Solve the wave equation using spherical means and address non-homogeneous equations.	**Ap**
3	Explain generalized coordinates, distinguish holonomic and non-holonomic systems, scleronomic and rheonomic systems. Illustrate generalized potential and Lagrange's equations of first and second kind. Utilize energy equations to analyze conservative fields and manipulate Hamilton's variables. Explain Donkin's theorem, Hamilton's canonical equations, cyclic coordinates and Routh's equations.	**U**
4	Analyze Poisson's Bracket, Poisson's Identity, and the Jacobi-Poisson Theorem. Apply calculus of variations to problems of shortest distance, minimum surface of revolution, brachistochrone problem, isoperimetric problem, and geodesic. Derive Euler's equation with 'n' dependent functions and higher-order derivatives. Evaluate conditional extremum problems.	**An**
5	Compute attraction and potential of rod, disc, spherical shells, and sphere. Apply surface integrals and Gauss theorem in normal attraction. Describe Laplace and Poisson equations, evaluate work done by self-attracting systems and determine distributions for a given potential. Associate surface density and surface harmonics.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	1	2	1	-	1	2	3	3	2	-	2
CO2	3	3	3	1	2	1	2	1	-	1	2	3	3	2	-	1
CO3	3	3	3	1	2	1	2	1	-	1	2	3	3	2	-	-
CO4	3	3	3	1	2	1	2	2	-	1	2	3	3	2	-	-
CO5	3	3	3	1	2	1	2	2	-	1	2	3	3	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Examples of PDE. Classification. Transport Equation-Initial Value Problem. Non-homogeneous Equation. Laplace's Equation-Fundamental Solution, Mean Value Formulas, Properties of Harmonic Functions, Green's Function, Energy Methods.	12	1
II	Heat Equation-Fundamental Solution, Mean Value Formula, Properties of Solutions, Energy Methods. Wave Equation-Solution by Spherical Means, Non-homogeneous Equations, Energy Methods.	12	2
III	Generalized coordinates. Holonomic and Non-holonomic systems. Scleronomic and Rheonomic systems. Generalized potential. Lagrange's equations of first kind. Lagrange's equations of second kind. Uniqueness of solution. Energy equation for conservative fields. Hamilton's variables. Donkin's theorem. Hamilton canonical equations. Cyclic coordinates. Routh's equations.	18	3
IV	Poisson's Bracket. Poisson's Identity. Jacobi-Poisson Theorem. Motivating problems of calculus of variations, Shortest distance. Minimum surface of revolution. Brachistochrone problem. Isoperimetric problem. Geodesic. Fundamental lemma of calculus of variations. Euler's equation for one dependent function and its generalization to (1) 'n' dependent functions, (ii) higher order derivatives. Conditional extremum under geometric constraints and under integral constraints.	15	4
V	Attraction and potential of rod, disc, spherical shells and sphere. Surface integral of normal attraction (application & Gauss' theorem). Laplace and Poisson equations. Work done by self-attracting systems. Distributions for a given potential. Equipotential surfaces. Surface and solid harmonics. Surface density in terms of surface harmonics.	18	5

Books Recommended:

1. L.C. Evans, *Partial Differential Equations*, American Mathematical Society, 1998.
2. F. Gantmacher, *Lectures in Analytic Mechanics*, MIR Publishers, Moscow, 1975.
3. R.C.Mondal, *Classical Mechanics*, Prentice Hall of India, 2001
4. S.L. Loney, *An Elementary Treatise on Statics*, Kalyani Publishers, New Delhi, 1979.

Reference Books:

1. I.N.Sneddon*, Elements of Partial Differential Equations*, Dover Publication, 2006.
2. F. John, *Partial Differential Equations*, Springer, 1991
3. P.Prasad & R.Ravindran, *Partial Differential Equations*, New Age International Publishers, 1985.
4. T.Amarnath, *Elementary Course in Partial Differential Equations*, Alpha Science International Ltd, 2003.
5. A.S. Ramsey, *Dynamics Part II*, Cambridge University Press, 1972.
6. H. Goldstein, *Classical Mechanics,* Narosa Publishing House, 2001.
7. I.M. Gelfand and S.V. Fomin, Calculus of Variations, Dover Publication, 2000.
8. N.C. Rana & P.S. Chandra Joag, Classical Mechanics, Tata McGraw Hill, 1991.
9. L. N. Hand & J.D. Finch, *Analytical Mechanics*, Cambridge University Press, 1998.
10. A.S. Ramsey, *Newtonian Gravitation*, Cambridge University Press. 1981.

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT331	**FUNDAMENTALS OF COMPUTER SCIENCE (OOPs and Data Structure)**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3 (T) + 2 (P)=5	3	1	4
Maximum Marks	CIA	ESE	
100	30	50 Theory + 20 Practical	

Learning Objective (LO):

The aim of this course is to build strong understanding of object-oriented programming principles and data structures among students. Equip the students with the knowledge and skills required to implement and analyze algorithms, utilize various data structures, and efficiently sort data.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain fundamental concepts and advanced topics related to OOP, including Classes and Scope, Nested Classes, Pointer Class Members, Class Initialization, Assignment, and Destruction.	**U**
2	Employ Overloaded Functions and Operators, Templates (including Class Templates), Class Inheritance, and Virtual Functions to design and implement complex software solutions.	**Ap**
3	Analyze algorithms using q,W,O,o,w notations. Implement and manipulate data structures using Sequential and Linked Representations, Lists, Stacks, and Queues.	**An**
4	Describe tree structures, focusing on Binary Trees. Design and manipulate Binary Trees.	**Ap**
5	Create, evaluate, and implement efficient algorithms using various sorting techniques, including Insertion Sort, Shell Sort, Quick-Sort, Heap Sort.	**E**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO2	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO3	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO4	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO5	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Object Oriented Programming-Classes and Scope, nested classes, pointer class members; Class initialization, assignment and destruction.	9	1
II	Overloaded functions and operators; Templates including class templates; class inheritance and virtual functions.	9	2
III	Data Structures-Analysis of algorithms, q, W, 0, o, w notations; Sequential and linked representations, Lists, Stacks, and queues;	9	3
IV	Trees: Binary tree- search tree implementation, B-tree (concept only);	9	4
V	Sorting: Insertion sort, shell sort, quick-sort, heap sort and their analysis; Hashing-open and closed.	9	5

Reference Books:

1. S.B. Lipman, J. Lajoi & B. Moo, *C++ Primer*, Addison Wesley, 2012.
2. B. Stroustrup, *The C++ Programming Language*, Addison Wesley, 2013.
3. C.J. Date, *Introduction to Database Systems*, Pearson, 1999.
4. C. Ritehie, *Operating Systems-Incorporating UNIX and Windows*, BPB Publications, 2003.
5. M.A. Weiss, Data Structures and Algorithm Analysis in C++, Pearson Education India, 2007.

M.Sc. (Mathematics) Semester-III

<table>
<tr><td>Program</td><td>Subject</td><td>Year</td><td colspan="2">Semester</td></tr>
<tr><td>M.Sc.</td><td>Mathematics</td><td>2</td><td colspan="2">III</td></tr>
<tr><td>Course Code</td><td colspan="2">Course Title</td><td colspan="2">Course Type</td></tr>
<tr><td>MAT332</td><td colspan="2">FUZZY SET THEORY & ITS APPLICATIONS (I)</td><td colspan="2">Elective</td></tr>
<tr><td rowspan="2">Credit</td><td colspan="4">Hours Per Week (L-T-P)</td></tr>
<tr><td>L</td><td>T</td><td colspan="2">P</td></tr>
<tr><td>5</td><td>5</td><td>1</td><td colspan="2">--</td></tr>
<tr><td>Maximum Marks</td><td colspan="2">CIA</td><td colspan="2">EA</td></tr>
<tr><td>100</td><td colspan="2">30</td><td colspan="2">70</td></tr>
</table>

Learning Objective (LO):

The objective of this course is to equip students with the knowledge and skills to work with fuzzy sets, fuzzy relations, and possibility theory and apply them to various real-world problems.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Describe fuzzy sets, including their basic definitions, properties such as α-level sets and convexity, and fundamental operations on fuzzy sets. Explain various types of fuzzy sets, including Cartesian and algebraic products, bounded sum and difference, as well as t-norms and t-conorms.	**U**
2	Explain the Extension Principle in fuzzy mathematics, with a specific focus on Zadeh's extension principle. Illustrate the concepts of image and inverse image of fuzzy sets, as well as the fundamental properties and operations of fuzzy numbers.	**U**
3	Apply fuzzy relations on fuzzy sets, including composition of fuzzy relations. Perform Min-Max composition and explain its properties.	**Ap**
4	Analyze fuzzy equivalence relations and fuzzy compatibility relations. Solve solving fuzzy relation equations and explain fuzzy graphs, including similarity relations.	**An**
5	Describe Possibility Theory, including its fundamental concepts such as fuzzy measures, evidence theory, necessity measure, possibility measure, and possibility distribution. Relate possibility theory and fuzzy sets, as well as the distinguish possibility theory and probability theory.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO2	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO3	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO4	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO5	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Fuzzy sets-Basic definitions, α-level sets. Convex fuzzy sets. Basic operations on fuzzy sets. Types of fuzzy sets. Cartesian products, Algebraic products. Bounded sum and difference, t-norms and t-conorms.	15	1
II	The Extension Principle- The Zadeh's extension principle. Image and inverse image of fuzzy sets. Fuzzy numbers. Elements of fuzzy arithmetic.	15	2
III	Fuzzy Relations on Fuzzy sets, Composition of fuzzy relations. Min-Max composition and its properties.	15	3
IV	Fuzzy equivalence relations. Fuzzy compatibility relations. Fuzzy relation equations. Fuzzy graphs, Similarity relation.	15	4
V	Possibility Theory-Fuzzy measures. Evidence theory. Necessity measure. Possibility measure. Possibility distribution. Possibility theory and fuzzy sets. Possibility theory versus probability theory.	15	5

Reference Books:

1. H.J. Zmmemann, *Fuzzy Set Theory and Its Applications*, Allied Publishers Ltd. New Delhi, 1991.
2. G.J. Klir & B. Yuan, *Fuzzy Sets and Fuzzy Logic*, Prentice-Hall of India, New Delhi, 1995.

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT333	**MATHEMATICAL ECOLOGY**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--
Maximum Marks	CIA	EA	
100	30	70	

Learning Objective (LO):

The objective of the course is to provide students a comprehensive understanding of various population models and their applications in ecology. Equip them with the capability to analyze ecological systems, predict population dynamics, and make informed decisions related to harvesting and conservation.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Apply quantitative techniques, such as phase plane analysis for ordinary differential equations. Describe exponential growth models, the logistic population model and qualitative analysis of continuous population model. Demonstrate the effects of harvesting on population models, including constant-yield harvesting and constant-effort harvesting.	**U**
2	Illustrate discrete population models, including linear models, equilibrium analysis, graphical solution of difference equations, and the explore period-doubling and chaotic behavior. Evaluate complex systems such as two-age group models and delayed recruitment.	**U**
3	Illustrate models for interacting species, such as the Lotka-Volterra equations and the chemostat. Identify equilibria, linearize systems, and provide qualitative solutions to linear systems, as well as recognizing the occurrence of periodic solutions and limit cycles.	**Ap**
4	Evaluate continuous models for two interacting populations, such as species competition, predator-prey systems, Kolmogorov models, and mutualism. Discuss the nature of interactions between species, including their roles in coexistence and invasive species dynamics. Draw conclusions about population dynamics of three interactive species.	**An**
5	Evaluate and optimize harvesting strategies within two-species models, including species in competition and predator-prey systems. Analyze the economic aspects of harvesting and apply mathematical techniques to optimize harvesting returns.	**E**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	3	3	2	2	2	3	3	2	3	3	1	-
CO2	3	3	3	1	3	3	2	2	2	3	3	2	3	3	1	-
CO3	3	3	3	1	3	3	2	2	2	3	3	2	3	3	1	-
CO4	3	3	3	1	2	3	2	2	2	3	3	2	3	3	1	-
CO5	3	3	3	1	2	3	2	2	2	3	3	2	3	3	1	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Continuous Population Models: Phase plane analysis of ODE. Exponential Growth model, the Logistic Population Model, qualitative analysis, harvesting in Population Models, Constant-yield harvesting, constant-effort harvesting, a case study of eutrophication of a lake.	15	1
II	Discrete Population Models: Linear Models, graphical solution of difference equations, equilibrium analysis, period-doubling and chaotic behavior, discrete-time metered models, two-age group model and delayed recruitment, a case study of oscillation in flour beetle populations.	14	2
III	Models for interacting species: The Lotka-Volterra equations, the chemostat, equilibria and linearization, qualitative solutions of linear systems, periodic solutions and limit cycles, models for giving up smoking and retaining of workers by their peers.	14	3
IV	Continuous Models for Two Interacting Populations: Species in competitions, Predator-Prey system, Kolmogorov Models, Mutualism, the community matrix, the nature of interactions between species, invading species and coexistence, a predator and two competing prey, two predators competing for prey.	20	4
V	Harvesting in Two-Species Models: Harvesting of species in competition, Harvesing of predator-prey systems, some economic aspects of harvesting, optimization of harvesting returns.	12	5

Books Recommended:

1. Fred Brauer, Carlos Castillo-Chavez, *Mathematical Models in Population Biology and Epidemiology*, Springer (2010)

Reference Books:

1. Nicholas F. Britton, *Essential Mathematical Biology*, Springer-Verlag (2003)
2. Mark Kot, *Elements of Mathematical Ecology*, Cambridge University Press (2003)
3. Eligabeth S. Allman, John A. Rhoades, *Mathematical Models in Biology*: *An Introduction*, Cambridge University Press (2004)
4. Mimmo Iannelli, Andrea Pugliese, *An Introduction to Mathematical Population Dynamics*, Springer (2014)
5. Linda J.S. Allen, *An Introduction to Mathematical Biology*, Pearson Education (2007)
6. J.D.Murray, *Mathematical Biology I. An Introduction*, Springer-Verlag (2002) 3rd Edition

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT341	**OPERATIONS RESEARCH (I)**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	EA
100	30	70

Learning Objective (LO):

The objective of this course is to provide students with a comprehensive understanding of Operations Research and its practical applications. The course aims to equip students with knowledge and skills in various domains, including linear programming, network analysis, transportation, and assignment problems. It also aims to enable students to learn about optimization techniques and apply them effectively in practical scenarios.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Identify role of Operations Research in various sectors. Formulate linear programming problems (LPP) and apply Simplex Method to solve LPP.	**U**
2	Evaluate the duality of linear programming models, conduct sensitivity analysis, and apply the Dual Simplex Method and other relevant algorithms to solve complex linear programming models.	**Ap**
3	Analyze and manipulate linear programming models using parametric method, Upper Bound Technique and Interior Point Algorithm. Illustrate Linear Goal Programming.	**An**
4	Formulate, analyze and solve Transportation and Assignment Problems.	**Ap**
5	Apply advanced problem-solving techniques related to Network Analysis, including solving Shortest Path, Minimum Spanning Tree, Maximum Flow, and Minimum Cost Flow Problems. Employ the Network Simplex Method and Project Planning and Control techniques such as PERT-CPM.	**An**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	3	2	2	2	2	1	1	2	2	1	3	2	1	3
CO2	3	2	3	2	3	2	2	1	1	3	2	1	3	2	1	3
CO3	3	2	3	2	3	2	2	1	1	2	2	1	3	2	1	3
CO4	3	2	3	2	3	2	2	2	1	3	2	1	3	2	1	3
CO5	3	2	3	2	2	2	3	1	1	2	2	1	3	2	1	1

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Operations Research and its Scope. Necessity of Operations Research in Industry. Linear Programming-Simplex Method. Theory of the Simplex Method.	15	1
II	Duality and Sensitivity Analysis. Other Algorithms for Linear Programming-Dual Simplex Method.	14	2
III	Parametric Linear Programming. Upper Bound Technique. Interior Point Algorithm. Linear Goal Programming.	16	3
IV	Transportation and Assignment Problems.	12	4
V	Network Analysis-Shortest Path Problem. Minimum Spanning Tree Problem. Maximum Flow Problem. Minimum Cost Flow Problem. Network Simplex Method. Project Planning and Control with PERT-CPM.	18	5

Books Recommended:

1. F.S. Hillier & G.J. Lieberman. *Introduction to Operations Research*, McGraw Hill International Edition, 1995.
2. G. Hadley, *Linear Programming*, Narosa Publishing House, 1995.
3. G. Hadley, *Nonlinear and Dynamic Programming*, Addison-Wesley, 1964
4. H.A. Taha, *Operations Research -An introduction*, Pearson Education, 2019.
5. Kanti Swarup, P.K. Gupta & Man Mohan, *Operations Research*, S. Chand & Sons, 2010.
6. Mokhtar S. Bazaraa, John J. Jarvis & Hanif D. Sherali, *Linear Programming and Network Flows*, John Wiley & Sons, New York, 1990.

Reference Books:

1. S.S. Rao, *Optimization Theory and Applications*, Wiley Eastern Ltd., 1979.
2. P.K. Gupta & D.S. Hira, *Operations Research-An Introduction*. S. Chand & Sons., 1976.
3. N.S. Kambo, *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., 2008.
4. M.S. Bazara, J.J. Jarvis, & H.D. Sherali, *Linear Programming and Network Flows*, Wiley, 2004.
5. S.J. Chandra & A. Mehra*, Numerical Optimization with Applications*, Narosa Publishing,2009
6. S.I., Gass, *Linear Programming- Methods and Applications*, Dover Publishers,2003.
7. A. Ravindran, D.T. Phillips & J.J. Solberg, *Operations Research- Principles and Practice*, Wiley India (P.) Ltd. (2005)
8. P.R. Thie & G.E. Keough, *An Introduction to Linear Programming and Game Theory*, John Wiley & Sons (2008).
9. A.T. Hamdy, *Operation Research: An Introduction*, Prentice-Hall of India Pvt. Ltd., 2002.

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT342	**WAVELETS (I)**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	EA
100	30	70

Learning Objective (LO):

The course aims to equip students with the knowledge and skills required to comprehend, generate, and utilize wavelet functions in a range of domains, including signal processing, image compression, and data analysis.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Examine the different methods of constructing wavelets, including the utilization of orthonormal bases generated by a single function, the implications of the Balian-Low theorem, and the role of smooth projections in the context of $L^2(R)$.	**An**
2	Apply local sine and cosine bases to construct various wavelets, and utilize unitary folding operators to achieve smooth projections.	**Ap**
3	Describe multiresolution analysis techniques to construct compactly supported wavelets and estimates for their smoothness. Explore the concept of band-limited wavelets.	**U**
4	Apply and compare different characterizations of wavelets, including Lemarie-Meyer wavelets, Franklin wavelets, and Spline wavelets on the real line.	**Ap**
5	Illustrate orthonormal bases for piecewise linear continuous functions in the context of L2(T), orthonormal bases for periodic splines.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO2	3	3	3	-	2	-	2	1	-	2	2	3	1	2	-	-
CO3	3	3	3	-	2	-	2	1	-	2	2	3	1	2	-	-
CO4	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO5	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Preliminaries-Different ways of constructing wavelets-Orthonormal bases generated by a single function: The Balian-Low theorem. Smooth projections on $L^2(R)$.	15	1
II	Local sine and cosine bases and the construction of some wavelets. The unitary folding operators and the smooth projections.	15	2
III	Multiresolution analysis and construction of wavelets. Construction of compactly supported wavelets and estimates for its smoothness. Band limited wavelets.	15	3
IV	Orthonormality. Completeness. Characterization of Lemarie-Meyer wavelets and some other characterizations. Franklin wavelets and Spline wavelets on the real line.	15	4
V	Orthonormal bases of piecewise linear continuous functions for $L^2(T)$. Orthonormal bases of periodic splines. Periodization of wavelets defined on the real line.	15	5

Reference Books:

1. E. Hernandez & G.Weiss, *A First Course on Wavelets*, CRC Press, New York, 1996.
2. C.K. Chui, *An Introduction to Wavelets*, Academic Press, 1992.
3. I.Daubechies, *Ten Lectures on Wavelets*, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, 1992.
4. Y.Meyer, *Wavelets - Algorithms and Applications*, SIAM, 1993.
5. M.V. Wickerhauser, *Adapted Wavelet Analysis: From Theory to Software*, CRC Press, 1994.

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT351	**PROGRAMMING IN C (WITH ANSI FEATURES) (I)** **Theory & Practical**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3 (T) + 2 (P)=5	3	1	4

Maximum Marks	CIA	ESE
100	30	50 Theory + 20 Practical

Learning Objective (LO):

The objectives of this course are to provide students with a strong foundation in C programming. This includes enabling them to write efficient and well-structured C code, understand data types and pointers, and effectively use control flow structures and operators to create functional programs.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain fundamental C-language, including functions, variables, constants, expressions, assignment statements, source code formatting, and preprocessor.	**U**
2	Describe scalar data types, declaration and initialization of variables, type conversions through casts, enumeration types. Use typedefs, and use pointers to find memory address.	**U**
3	Apply knowledge of control flow including conditional branching, switch statement. Utilize break and continue statements and handle infinite loops.	**Ap**
4	Illustrate functionality of operators such as unary, binary arithmetic, relational, logical, bitwise, conditional operators and memory operators to manipulate data.	**An**
5	Manipulate arrays, including declaration, initialization and apply arrays in loops. Explain encryption and decryption of data.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	1	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-
CO2	1	1	2	3	3	3	2	2	2	1	2	1	1	-	3	-
CO3	1	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-
CO4	1	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-
CO5	1	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	An overview of programming. Programming language, Classification. C Essentials-Program Development. Functions. Anatomy of a C Function. Variables and Constants. Expressions. Assignment Statements. Formatting Source Files. Continuation Character. The Preprocessor.	8	1
II	Scalar Data Types-Declarations, Different Types of Integers. Different kinds of Integer Constants. Floating-Point Types. Initialization. Mixing Types. Explicit Conversions-Casts. Enumeration Types. The Void Data Type. Typedefs. Finding the Address of an object. Pointers.	8	2
III	Control Flow-Conditional Branching. The Switch Statement. Looping. Nested Loops. The break and continue Statements. The goto statement. Infinite Loops.	10	3
IV	Operators and Expressions-Precedence and Associativity. Unary Plus and Minus operators. Binary Arithmetic Operators. Arithmetic Assignment Operators. Increment and Decrement Operators. Comma Operator. Relational Operators. Logical Operators. Bit - Manipulation Operators. Bitwise Assignment Operators. Cast Operator. Size of Operators. Conditional Operator. Memory Operators.	10	4
V	Arrays -Declaring an Array. Arrays and Memory. Initializing Arrays. Encryption and Decryption.	9	5

Books Recommended:

1. Y.Kanetkar, Let Us C, BPB Publications, 2016.

Reference Books:

1. P.A. Darnell & P.E. Margolis, C: A Software Engineering Approach, Narosa Publishing House, 1993.
2. S.P.Harkison & G.L.Steele Jr., C: A Reference Manual, Prentice Hall, 1984.
3. B.W. Kernighan & D.M. Ritchie, The C Programme Language, (ANSI Features), Prentice Hall 1989.

M.Sc. (Mathematics) Semester-III

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT352	**GRAPH THEORY (I)**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The objective of this course is to provide students with a comprehensive understanding of graph theory and its various applications. The course aims to equip students with the knowledge and skills to perform operations on graphs, matrices, and vector spaces, as well as explore topics related to colorings, packings, and coverings.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Apply various operations on graphs, including topological operations, homeomorphism, homomorphism, and contractions.	**Ap**
2	Analyze matrices and vector spaces by examining properties such as the adjacency matrix, determinant, and spectrum. Apply these concepts in graph theory.	**An**
3	Evaluate graph properties related to coloring, covering, girth, and chromatic numbers. Solve graph coloring and covering problems and examine their effectiveness.	**E**
4	Set up combinatorial formulations for various graph-related problems. Apply theorems like Gallai and Norman-Rabin theorems, and solve combinatorial problems.	**Ap**
5	Analyze the concept of perfect graphs and various graph classes, including split, triangulated, interval, and weakly triangulated graphs.	**An**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO2	3	3	3	-	2	-	2	1	-	2	2	3	1	2	-	-
CO3	3	3	3	-	3	-	2	1	-	2	2	3	1	2	-	-
CO4	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO5	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Operations on graphs, matrices and vector spaces: Topological operations, Homeomerphism, homomorphism, contractions, derived graphs, Binary operations.	15	1
II	Matrices and vector spaces: Matrices and vector spaces : The adjacency matrix, The determinant and the spectrum, Spectrum properties, The incidence matrix, cycle space and Bond space, Cycle bases and cycle graphs.	15	2
III	Colouring packing and covering: Vertex coverings, critical graphs, Girth and chromatic number, uniquely colourable graphs, edge-colourings, Face colourings and Beyond, The achromatic and the Adjoint Numbers.	15	3
IV	Combinational formulations: Setting up of combinational formulations, the classic pair of duals, Gallai, Norman-Rabin Theorems, Clique parameters, The Rosenfeld Numbers.	15	4
V	Perfect Graphs: Introduction to the "SPGC", Triangulated (Chordal) graphs, Comparability graphs, Interval graphs, permutation graphs, circular arc graphs, split graphs, weakly triangulated graphs.	15	5

Books Recommended:

1. K.R.Parthasarathy, *Basic graph theory*, Tata Mcgraw Hill Publishing Company Limited , 1994.

Reference Books:

1. R.J.Wilson, *Introduction to Graph Theory*, Longman Harlow, 1985.
2. J. Clark, D.A. Holton, *A First Look at Graph Theory*, World Scientific Singapore, 1991.
3. F. Hararary, *Graph Theory*, Narosa, New Delhi, 1995.
4. R. Gould, *Graph Theory*, The Benjamin/Cummins Publ. Company, 1988.
5. N. Deo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice-Hall of India, 2002.

M.Sc. (Mathematics) Semester-III

(Offered to PG students of SoS in Mathematics only)

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT353	**NUMBER THEORY**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The objective of this course is to provide students with a solid understanding of fundamental concepts in number theory. The course aims to equip students with the knowledge and skills necessary to explore divisibility and distribution of prime numbers, congruences and related theorems, number theoretic functions, primitive roots, quadratic residues, and Diophantine equations.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Apply fundamental concepts such as the division algorithm, Euclidean algorithm, and the Fundamental Theorem of Arithmetic to solve problems related to divisibility and prime numbers.	**Ap**
2	Analyze congruences, their basic properties, and linear congruences. Understand and apply important theorems like the Chinese Remainder Theorem, Fermat's Theorem, Wilson's Theorem, and Euler's Theorem.	**An**
3	Evaluate number theoretic functions, including the greatest integer function, arithmetic functions, divisor functions, and the Mobius Inversion formula.	**E**
4	Apply knowledge of primitive roots, quadratic residues, and the theory of indices to solve problems involving quadratic equations. Utilize concepts like Euler's criterion, quadratic reciprocity, and Legendre and Jacobi symbols in their problem-solving approaches.	**U**
5	Apply number theory principles to solve Diophantine equations, including linear Diophantine equations, Pythagorean triples, and Pell's equation. Demonstrate problem solving abilities in advanced topics such as Fermat's Last Theorem, elliptic curves, continued fractions, and Farey fractions.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	3	1	2	2	-	2	2	3	1	2	-	3
CO2	3	3	3	-	3	1	2	2	-	2	2	3	1	2	-	3
CO3	3	3	3	-	3	1	2	2	-	2	2	3	1	2	-	-
CO4	3	3	3	-	3	1	2	2	-	2	2	3	1	2	-	-
CO5	3	3	3	-	3	1	2	2	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Divisibility and Distribution of prime numbers: division algorithm, Euclidean Algorithm, Primes, Fundamental theorem of arithmetic, distribution of primes, numbers of special forms	15	1
II	Congruences: basic definitions and properties, linear congruences, Chinese Remainder Theorem, Fermat's theorem, Wilson's theorem, Euler's theorem.	14	2
III	Number theoretic functions: Greatest integer function, Arithmetic Functions, divisor function, the Mobius Inversion formula, recurrence function.	16	3
IV	Primitive roots and Quadratic residues: primitive roots, theory of indices, quadratic residues, Quadratic residue, Euler's criterion, quadratic reciprocity, Legendre and Jacobi symbol, Binary Quadratic Forms	15	4
V	Diophantine equations: linear Diophantine equations, Pythagorean triples, Fermat's last theorem, Elliptic Curves, Pell's equation, Continued Fractions, Farey fraction.	15	5

Books Recommended:

1. David M Burton, *Elementary Number Theory*, McGraw Hill Companies, 7th Edition 2007.
2. Thomas Koshy, Elementary Number Theory with Applications, Elsevier, 2007.

Reference Books:

1. K. Ireland and M. Rosen, *A Classical Introduction to Modern Number Theory*, Springer-Verlag, Berlin, 1990.
2. S. Lang, *Algebraic Number Theory*, Addison- Wesley, 1970.
3. I. Niven, H.S. Zuckerman & H.L. Montgomery, *An Introduction to the Theory of Numbers*, Wiley, 2008.
4. T. M. Apostal, *Introduction to Analytic Number Theory*, Narosa Publishers, 1998

M.Sc. (Mathematics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	IV
Course Code	Course Title		Course Type
MAT410	**FUNCTIONAL ANALYSIS (II)**		Core
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	0

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The aim of this course is to empower students with a profound understanding of advanced concepts in functional analysis and Hilbert spaces. Through this course, students will acquire the essential knowledge and skills necessary to proficiently work with various types of operators and variational problems.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Apply the Uniform Boundedness Theorem and describe its implications in various mathematical contexts. Analyze the Open Mapping Theorem and Closed Graph Theorem.	**Ap**
2	Describe the Hahn-Banach theorem in the contexts of real, complex and normed linear spaces. Explain the concept of reflexive spaces and sequential compactness. Express compact operators and the Closed Range Theorem.	**U**
3	Describe inner product spaces, including properties of inner products, orthogonality, and the concept of Hilbert spaces. Analyze and apply orthonormal sets, Bessel's inequality. Explain complete orthonormal sets and Parseval's identity.	**An**
4	Explain Hilbert spaces, apply Projection Theorem to solve problems related to orthogonal projections. Illustrate Riesz Representation Theorem. Describe concept of adjoint operators and significance of reflexivity of Hilbert spaces.	**U**
5	Analyze and apply concepts related to self-adjoint, positive, projection, normal, and unitary operators. Explain abstract variational boundary-value problems and apply the Generalized Lax-Milgram Theorem.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	2	1	2	-	2	1	-	1	1	3	1	2	-	-
CO2	3	3	3	2	2	-	2	1	-	1	1	3	1	2	-	-
CO3	3	3	3	2	2	1	2	1	-	2	1	3	1	2	-	2
CO4	3	3	3	2	2	1	2	1	-	2	1	3	1	2	-	1
CO5	3	3	3	1	2	1	2	1	-	2	1	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Uniform boundedness theorem and some of its consequences. Open mapping and closed graph theorems.	15	1
II	Hahn-Banach theorem for real linear spaces, complex linear spaces and normed linear spaces. Reflexive spaces. Weak Sequential Compactness. Compact Operators. Solvability of linear equations in Banach spaces. The closed Range Theorem.	17	2
III	Inner product spaces. Hilbert spaces. Orthonormal Sets. Bessel's inequality. Complete orthonormal sets and Parseval's identity.	16	3
IV	Structure of Hilbert spaces. Projection theorem. Riesz representation theorem. Adjoint of an operator on a Hilbert space. Reflexivity of Hilbert spaces.	13	4
V	Self-adjoint operators, Positive, projection, normal and unitary operators. Abstract variational boundary-value problem. The generalized Lax-Milgram theorem.	14	5

Books Recommended:

1. P.R. Halmos, *Measure Theory*, Van Nostrand, Princeton, 1950.
2. B.Choudhary and S.Nanda, *Functional Analysis with Applications*, Wiley Eastern Ltd. 1989.
3. H.L. Royden, *Real Analysis*, Macmillan Publishing Co. Inc., New York, 1993.

Reference Books:

1. S.K. Berberian, *Measure and integration*, Chelsea Publishing Company, New York, 1965.
2. G. de Barra, *Measure Theory and Integration*, Wiley Eastern Limited, 1981.
3. P.K. Jain and V.P. Gupta, *Lebesgue Measure and Integration*, New Age International Pvt. Ltd., New Delhi, 2000.
4. Richard L. Wheeden and Antoni Zygmund, *Measure and Integral : An Introduction to Real Analysis*, Marcel Dekker Inc. 1977.
5. J.H. Williamson, *Lebesgue Integration*, Holt Rinehart and Winston, Inc. New York. 1962.
6. T.G. Hawkins, *Lebesgue's Theory of Integration: Its Origins and Development*, Chelsea, New York, 1979.
7. K.R. Parthasarathy, *Introduction to Probability and Measure*, Macmillan Company of India Ltd., Delhi, 1977.
8. R.G. Bartle, *The Elements of Integration*, John Wiley & Sons, Inc. New York, 1966.
9. Serge Lang, *Analysis I & II*, Addison-Wesley Publishing Company, Inc. 1967.
10. Inder K. Rana, *An Introduction to Measure and Integration*, Narosa Publishing House, Delhi, 1997.

11. Walter Rudin, *Real & Complex Analysis*, Tata McGraw-Hill Publishing Co.Ltd. New Delhi, 1966.
12. Edwin Hewitt and Kenneth A. Ross, *Abstract Harmonic Analysis*, Vol. 1, Springer-Verlag, 1993.
13. G. Bachman and L. Narici, *Functional Analysis*, Academic Press, 1966.
14. N. Dunford and J.T. Schwartz, *Linear Operators, Part* I, Interscience, New York, 1958.
15. R.E. Edwards, *Functional Analysis*, Holt Rinehart and Winston, New York, 1965.
16. C. Goffman and G. Pedrick, *First Course in Functional Analysis*, Prentice Hall of India, New Delhi, 1987.
17. P.K. Jain, O.P. Ahuja and Khalil Ahmad, *Functional Analysis*, New Age International (P) Ltd. & Wiley Eastern Ltd., New Delhi, 1997.
18. R.B. Holmes, *Geometric Functional Analysis and its Applications*, Springer-Verlag, 1975.
19. K.K. Jha, *Functional Analysis*, Students' Friends, 1986.
20. L.V. Kantorovich and G.P. Akilov, *Functional Analysis*, Pergamon Press, 1982.
21. E. Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley & Sons, New York, 1978.
22. B.K. Lahiri, *Elements of Functional Analysis*, The World Press Pvt. Ltd., Calcutta, 1994.
23. A.H.Siddiqui, *Functional Analysis with Applications*, Tata McGraw-Hill Publishing Company Ltd. New Delhi
24. B.V. Limaye, *Functional Analysis*, Wiley Eastern Ltd.
25. L.A. Lustenik and V.J. Sobolev, *Elements of Functional Analysis*, Hindustan Publishing Corporation, New Delhi, 1971.
26. G.F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill Book Company, New York, 1963.
27. A.E. Taylor*, Introduction to Functional Analysis*, John Wiley and Sons, New York, 1958.
28. K.Yosida, *Functional Analysis*, Springer-Verlag, New York, 1971.
29. J.B. Conway, *A Course in Functional Analysis*, Springer-Verlag, New York, 1990.
30. Walter Rudin, *Functional Analysis*, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 1973.
31. A. Wilansky, *Functional Analysis*, Blaisdell Publishing Co., 1964.
32. J. Tinsley Oden & Leszek F. Dernkowicz, *Applied Functional Analysis*, CRC Press Inc., 1996.

M.Sc. (Mathematics) Semester-IV

<table>
<tr><td>Program</td><td>Subject</td><td colspan="2">Year</td><td>Semester</td></tr>
<tr><td>M.Sc.</td><td>Mathematics</td><td colspan="2">2</td><td>IV</td></tr>
<tr><td>Course Code</td><td colspan="3">Course Title</td><td>Course Type</td></tr>
<tr><td>MAT420</td><td colspan="3">PARTIAL DIFFERENTIAL EQUATIONS & MECHANICS (II)</td><td>Core</td></tr>
<tr><td rowspan="2">Credit</td><td colspan="4">Hours Per Week (L-T-P)</td></tr>
<tr><td>L</td><td colspan="2">T</td><td>P</td></tr>
<tr><td>5</td><td>5</td><td colspan="2">1</td><td>0</td></tr>
<tr><td>Maximum Marks</td><td colspan="2">CIA</td><td colspan="2">ESE</td></tr>
<tr><td>100</td><td colspan="2">30</td><td colspan="2">70</td></tr>
</table>

Learning Objective (LO):

The objective of this course is to create a deep understanding of advanced topics in partial differential equations and analytical dynamics. It aims to equip students with the knowledge and skills to utilize techniques from nonlinear PDEs, analytical dynamics, and methods for asymptotic and power series solutions. Additionally, the course aims to develop students' understanding of principles related to Hamilton's equations, canonical transformations, and their applications.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Solve nonlinear first order PDE using complete integrals, envelopes, characteristics. Solve Hamilton-Jacobi equations. Apply calculus of variations to derive Hamilton's ODE, Legendre transforms, and the Hopf-Lax formula. Illustrate conservation laws, shocks, entropy conditions, and weak solutions.	**Ap**
2	Analyze and solve partial differential equations using Separation of Variables, Similarity Solutions. Transform PDE through Fourier and Laplace Transform, Hopf-Cole Transform, Hodograph and Legendre Transforms, and Potential Functions.	**An**
3	Apply asymptotic analysis to illustrate Singular Perturbations, Laplace's Method, Geometric Optics, Stationary Phase, and Homogenization. Employ Non-characteristic Surfaces, Real Analytic Functions, and the Cauchy-Kovalevskaya Theorem to obtain power series solution of PDEs.	**U**
4	Describe and apply Hamilton's Principle, the Principle of Least Action, Poincare Cartan Integral Invariant, Whittaker's Equations, Jacobi's Equations, Lee Hwa Chung's Theorem, Canonical Transformations, and the Properties of Generating Functions.	**Ap**
5	Explain Hamilton-Jacobi equation, Jacobi Theorem, Method of Separation of Variables, Lagrange Brackets, and the Conditions of Canonical Character of a transformation expressed through Lagrange Brackets and Poisson Brackets. Apply separation techniques, and evaluate canonical transformations.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	2	1	2	1	-	1	2	3	3	2	-	2
CO2	3	3	3	1	2	1	2	1	-	1	2	3	3	2	-	1
CO3	3	3	3	1	2	1	2	1	-	1	2	3	3	2	-	-
CO4	3	3	3	1	2	1	2	2	-	1	2	3	3	2	-	-
CO5	3	3	3	1	2	1	2	2	-	1	2	3	3	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Nonlinear First Order PDE-Complete Integrals, Envelopes, Characteristics, Hamilton Jacobi Equations (Calculus of Variations, Hamilton's ODE, Legendre Transform, Hopf-Lax Formula, Weak Solutions, Uniqueness), Conservation Laws (Shocks, Entropy Condtion, LaxOleinik formula, Weak Solutions, Uniqueness, Riemann's Problem, Long Time Behaviour)	18	1
II	Representation of Solutions-Separation of Variables, Similarity Solutions (Plane and Travelling Waves, Solitons, Similarity under Scaling), Fourier and Laplace Transform, Hopf-Cole Transform, Hodograph and Legendre Transforms, Potential Functions.	15	2
III	Asymptotics (Singular Perturbations, Laplace's Method, Geometric Optics, Stationary Phase, Homogenization), Power Series (Non-characteristic Surfaces, Real Analytic Functions, Cauchy-Kovalevskaya Theorem).	15	3
IV	Hamilton's Principle. Principle of least action. Poincare Cartan Integral invariant. Whittaker's equations. Jacobi's equations. Lee Hwa Chung's theorem, canonical transformations and properties of generating functions.	13	4
V	Hamilton-Jacobi equation. Jacobi theorem. Method of separation of variables. Lagrange Brackets. Condition of canonical character of a transformation in terms of Lagrange brackets and Poisson brackets, invariance of Lagrange brackets and Poisson brackets under canonical transformations.	14	5

Books Recommended:

1. L.C. Evans, *Partial Differential Equations*, American Mathematical Society, 1998.
2. F. Gantmacher, *Lectures in Analytic Mechanics*, MIR Publishers, Moscow, 1975.
3. R.C.Mondal, *Classical Mechanics*, Prentice Hall of India, 2001

Reference Books:

1. I.N.Sneddon, *Elements of Partial Differential Equations*, Dover Publication, 2006.
2. F. John, *Partial Differential Equations*, Springer, 1991
3. P.Prasad & R.Ravindran, *Partial Differential Equations*, New Age International Publishers, 1985.
4. T.Amarnath, *Elementary Course in Partial Differential Equations*, Alpha Science International Ltd, 2003.
5. A.S. Ramsey, *Dynamics Part II*, Cambridge University Press, 1972.

6. H. Goldstein, *Classical Mechanics,* Narosa Publishing House, 2001.
7. I.M. Gelfand and S.V. Fomin, Calculus of Variations, Dover Publication, 2000.
8. N.C. Rana & P.S. Chandra Joag, Classical Mechanics, Tata McGraw Hill, 1991.
9. L. N. Hand & J.D. Finch, *Analytical Mechanics*, Cambridge University Press, 1998.

M.Sc. (Mathematics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	IV
Course Code	Course Title		Course Type
MAT431	**OPERATING SYSTEM AND DATABASE MANAGEMENT SYSTEM**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3 (T) + 2 (P)=5	3	1	4

Maximum Marks	CIA	ESE
100	30	50 Theory + 20 Practical

Learning Objective (LO):

The primary objective of this course is to empower students with the fundamental principles required to work with databases and operating systems across diverse computing environments. It aims to develop an understanding of database systems, encompassing key concepts such as data modeling, relational databases, SQL, and database design, while also providing students with essential knowledge of operating systems.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Explain essential concepts, including the Role of Database Systems, Database System Architecture, and Data Modeling.	**U**
2	Describe key concepts, including Relational Algebra and Relational Calculus. Apply these concepts in the design, querying, and manipulation of relational databases.	**Ap**
3	Explain SQL fundamentals, encompassing basic features and views. They will apply higher-order cognitive skills such as analysis and synthesis to enforce integrity constraints effectively. Implement normalization up to Boyce-Codd Normal Form (BCNF) in database design.	**Ap**
4	Explain Unix-based operating systems, focusing on processor management, memory management, and user interfaces.	**U**
5	Describe advanced topics on Unix-based operating systems, including I/O Management, Concurrency, Security, and Network and Distributed Systems.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO2	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO3	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO4	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-
CO5	-	1	-	3	2	2	1	-	2	-	-	-	-	-	3	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Database Systems-Role of database systems, database system architecture and data modeling.	10	1
II	Introduction to relational algebra and relational calculus.	9	2
III	Introduction to SQL: Basic features including views; Integrity constraints; Database design-normalization up to BCNF.	9	3
IV	Operating Systems- Overview of operating system, user interface, processor management, memory management.	9	4
V	I/O management, concurrency and Security, network and distributed systems.	8	5

Reference Books:

1. S.B. Lipman, J. Lajoi & B. Moo, *C++ Primer*, Addison Wesley, 2012.
2. B. Stroustrup, *The C++ Programming Language*, Addison Wesley, 2013.
3. C.J. Date, *Introduction to Database Systems*, Pearson, 1999.
4. C. Ritehie, *Operating Systems-Incorporating UNIX and Windows*, BPB Publications, 2003.
5. M.A. Weiss, Data Structures and Algorithm Analysis in C++, Pearson Education India, 2007.

M.Sc. (Mathematics) Semester-IV

<table>
<tr><td>Program</td><td>Subject</td><td>Year</td><td>Semester</td></tr>
<tr><td>M.Sc.</td><td>Mathematics</td><td>2</td><td>IV</td></tr>
<tr><td>Course Code</td><td colspan="2">Course Title</td><td>Course Type</td></tr>
<tr><td>MAT432</td><td colspan="2">FUZZY SET THEORY & ITS APPLICATIONS (II)</td><td>Elective</td></tr>
<tr><td rowspan="2">Credit</td><td colspan="3">Hours Per Week (L-T-P)</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>5</td><td>5</td><td>1</td><td>--</td></tr>
</table>

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The aim of this course is to provide students with a strong foundation in fuzzy logic, approximate reasoning, and their practical applications across various domains, encompassing control systems and decision-making in uncertain environments.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Describe fuzzy logic, including an overview of classical logic, multivalued logics, and the fundamental principles of fuzzy logic. Illustrate fuzzy propositions, fuzzy quantifiers, linguistic variables, and hedges, and perform inference from conditional fuzzy propositions using the compositional rule of inference.	U
2	Employ approximate reasoning techniques in the context of Fuzzy Expert Systems. Select appropriate fuzzy implications and utilize them in multiconditional approximate reasoning scenarios. Indicate the crucial role of fuzzy relation equations in facilitating approximate reasoning processes.	Ap
3	Describe the principles of Fuzzy Control. Illustrate fuzzy controllers, fuzzification, and defuzzification methods. Design and implement fuzzy control systems for various applications.	An
4	Apply fuzzy mathematics principles to decision-making processes in various contexts including individual, multiperson, multicriteria, and multistage decision-making in a fuzzy environment. Model and analyze decision problems involving uncertainty and imprecision.	Ap
5	Apply fuzzy ranking methods to prioritize and rank alternatives under conditions of uncertainty and imprecision. Use fuzzy linear programming techniques to solve optimization problems with fuzzy constraints and objectives.	Ap

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO2	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO3	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO4	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-
CO5	3	3	3	1	1	1	2	1	-	2	2	3	2	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Fuzzy Logic-An overview of classical logic, Multivalued logics, Fuzzy propositions. Fuzzy quantifiers. Linguistic variables and hedges. Inference from conditional fuzzy propositions, the compositional rule of inference.	15	1
II	Approximate Reasoning-An overview of fuzzy expert system. Fuzzy implications and their selection. Multiconditional approximate reasoning. The role of fuzzy relation equation.	15	2
III	An introduction to Fuzzy Control-Fuzzy controllers. Fuzzification. Defuzzification and the various defuzzitication methods.	15	3
IV	Decision Making in Fuzzy Environment-Individual decision making. Multiperson decision making. Multicriteria decision making. Multistage decision making.	15	4
V	Fuzzy ranking methods. Fuzzy linear programming.	15	5

Reference Books:

1. H.J. Zmmemann, *Fuzzy Set Theory and Its Applications*, Allied Publishers Ltd. New Delhi, 1991.
2. G.J. Klir & B. Yuan, *Fuzzy Sets and Fuzzy Logic*, Prentice-Hall of India, New Delhi, 1995.

M.Sc. (Mathematics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	IV
Course Code	Course Title		Course Type
MAT433	**MATHEMATICAL EPIDEMIOLOGY**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The objective of this course is to provide students with a comprehensive understanding of epidemic models and their applications. The course aims to equip students with the capability to analyze disease dynamics, predict epidemic outcomes, and make informed decisions related to disease control and prevention.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Analyze and interpret epidemic models, including the Kermack-McKendrick model and its variations with exposed periods, treatment, quarantine, isolation, vaccination, and age-specific considerations. Calculate key parameters, and understand the impact of interventions.	**An**
2	Analyze and interpret endemic disease models, including models for diseases with no immunity, model with births and deaths. Determine herd immunity, age of infection, and inter-epidemic period. Describe epidemic approach to endemic equilibrium and the dynamics of diseases with temporary immunity.	**An**
3	Apply advanced techniques, including the Jacobian Approach, Routh-Hurwitz criteria, and the next-generation approach, for computing R0 in complex epidemiological models. Demonstrate proficiency in building models that encompass stages of disease progression, control strategies.	**Ap**
4	Apply the principles of local stability analysis to assess the dynamics of the SEIR model, employ Lyapunov functions to establish global stability, and the Lyapunov–Kasovskii–LaSalle stability theorems to analyze complex ODE epidemic models. Identify scenarios involving backward bifurcation.	**Ap**
5	Apply the competitive exclusion principle to understand the dynamics of two-strain epidemics within the SIR model. Assess two-strain models for coexistence, accurately identifying the existence and stability of disease-free, dominance, and coexistence equilibria. Compute invasion numbers using the next-generation approach.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	2	3	3	2	2	2	3	3	2	3	3	1	-
CO2	3	3	3	2	3	3	2	2	2	3	3	2	3	3	1	-
CO3	3	3	3	2	3	3	2	2	2	3	3	2	3	3	1	-
CO4	3	3	3	2	3	3	2	2	2	3	3	2	3	3	1	-
CO5	3	3	3	2	3	3	2	2	2	3	3	2	3	3	1	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Epidemic models: Introduction to epidemic models, simple Kermack-McKendrick epidemic model, models with exposed period, treatments models, an influenza model, quarantine-isolation models. An SIR model with a general infectious period, the age of infection epidemic model, models with disease deaths, a vaccination model.	16	1
II	Models for endemic diseases: A model for diseases with no immunity, the SIR model with births and deaths, some applications: Herd immunity, age of infection, the inter-epidemic period, epidemic approach to endemic equilibrium, the SIS model with births and deaths, temporary immunity, diseases population control.	14	2
III	Techniques for Computing R0: Building complex epidemiological models, stages related to disease progression, control strategies, pathogen or host heterogeneity. Jacobian Approach for the Computation of R0, examples in which the Jacobian reduces to a 2×2 matrix, Routh–Hurwitz criteria, failure of the Jacobian approach, the next-generation Approach.	14	3
IV	Analysis of Complex ODE Epidemic Models (Global Stability): Introduction, local analysis of the SEIR model, global stability via Lyapunov functions, Lyapunov–Kasovskii–LaSalle stability theorems, global stability of equilibria of the SEIR model, Hopf bifurcation in higher dimensions, backward bifurcation, example of backward bifurcation and multiple equilibria.	16	4
V	Multistrain Disease Dynamics: Competitive Exclusion Principle, two-strain epidemic SIR model, the strain-one- and strain-two-dominance equilibria and their stability, the competitive exclusion principle, Multistrain Diseases-Mechanisms for Coexistence, analyzing two-strain models with coexistence, existence and stability of the disease-free and two dominance equilibria, existence of the coexistence equilibrium, computing the invasion numbers using the next-generation approach.	15	5

Books Recommended:

1. Fred Brauer, Carlos Castillo-Chavez, Mathematical *Models in Population Biology and Epidemiology*, Springer (2010)
2. Maia Martcheva, *An Introduction to Mathematical Ep*idemiology, Springer (2015)

Reference Books:

1. Fred Brauer, P. van den Driessche, J. Wu, *Mathematical Epidemiology*, Springer (2008)
2. Nicholas F. Britton, *Essential Mathematical Biology*, Springer-Verlag (2003)
3. Fred Brauer, Carlos Castillo-Chavez, *Mathematical Models for Communicable Diseases*, SIAM (2013).
4. Paul Waltman, *Deterministic Threshold Models in the Theory of Epidemics* (1974)

M.Sc. (Mathematics) Semester-IV

<table>
<tr><th>Program</th><th>Subject</th><th colspan="2">Year</th><th>Semester</th></tr>
<tr><td>M.Sc.</td><td>Mathematics</td><td colspan="2">2</td><td>IV</td></tr>
<tr><td>Course Code</td><td colspan="3">Course Title</td><td>Course Type</td></tr>
<tr><td>MAT441</td><td colspan="3">OPERATIONS RESEARCH (II)</td><td>Elective</td></tr>
<tr><td rowspan="2">Credit</td><td colspan="4">Hours Per Week (L-T-P)</td></tr>
<tr><td>L</td><td colspan="2">T</td><td>P</td></tr>
<tr><td>5</td><td>5</td><td colspan="2">1</td><td>--</td></tr>
<tr><td>Maximum Marks</td><td colspan="2">CIA</td><td colspan="2">ESE</td></tr>
<tr><td>100</td><td colspan="2">30</td><td colspan="2">70</td></tr>
</table>

Learning Objective (LO):

The objective of this course is to provide students with a comprehensive understanding of various mathematical optimization techniques and their applications in decision-making processes. The course aims to equip students with the knowledge and skills to apply dynamic programming, game theory, integer programming, queueing theory, and nonlinear programming to real-world problems effectively.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Employ Dynamic Programming techniques, encompassing recursive equation and dynamic linear programming approaches. Describe Deterministic and Probabilistic Dynamic Programming methodologies.	**Ap**
2	Analyze and solve Two-Person, Zero-Sum Games and Games with Mixed Strategies. Apply Graphical Solution methods and employ Linear Programming techniques for strategic decision-making.	**An**
3	Solve Integer Programming problems, encompassing Pure and Mixed Integer Programming scenarios. Apply Gomory's All-I P.P. Method, construct Gomory's Constraints, and employ the Fractional Cut Method for both All Integer LPP and Mixed Integer LPP cases. Utilize the Branch and Bound Technique to tackle complex optimization problems.	**Ap**
4	Analyze Deterministic Queueing Systems, apply probability distributions in Queueing Models, and categorize diverse Queueing scenarios. Explain Poisson Queueing Systems.	**Ap**
5	Analyze Nonlinear Programming problems, both in one-variable and multi-variable unconstrained optimization scenarios. Apply the Kuhn-Tucker Conditions for Constrained Optimization and solve complex optimization challenges using Quadratic Programming, Separable Programming, Convex Programming, and handling the intricacies of Non-convex Programming.	**An**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	3	2	2	2	2	1	1	2	2	1	3	2	1	-
CO2	3	2	3	2	3	2	2	1	1	3	2	1	3	2	1	1
CO3	3	2	3	2	3	2	2	1	1	2	2	1	3	2	1	-
CO4	3	2	3	2	3	2	2	2	1	3	2	1	3	2	1	2
CO5	3	2	3	2	2	2	3	1	1	2	2	1	3	2	1	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Dynamic Programming, recursive equation approach, dynamic linear programming approach. Deterministic and Probabilistic Dynamic programming.	15	1
II	Game Theory-Two-Person, Zero-Sum Games. Games with Mixed Strategies. Graphical Solution. Solution by Linear Programming	12	2
III	Integer Programming-Pure and Mixed Integer Programming Problem, Gomory'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 Technique.	15	3
IV	Queueing system: Deterministic Queueing system, probability distribution in Queueing, classification of Queueing models, Poisson Queueing system.	16	4
V	Nonlinear Programming-One/and Multi-Variable Unconstrained Optimization. Kuhn-Tucker Conditions for Constrained Optimization. Quadratic Programming. Separable Programming. Convex Programming. Non-convex Programming.	17	5

Books Recommended:

1. F.S. Hillier & G.J. Lieberman. *Introduction to Operations Research*, McGraw Hill International Edition, 1995.
2. G. Hadley, *Linear Programming*, Narosa Publishing House, 1995.
3. G. Hadley, *Nonlinear and Dynamic Programming*, Addison-Wesley, 1964
4. H.A. Taha, *Operations Research -An introduction*, Pearson Education, 2019.
5. Kanti Swarup, P.K. Gupta & Man Mohan, *Operations Research*, S. Chand & Sons, 2010.
6. Mokhtar S. Bazaraa, John J. Jarvis & Hanif D. Sherali, *Linear Programming and Network Flows*, John Wiley & Sons, New York, 1990.

Reference Books:

1. S.S. Rao, *Optimization Theory and Applications*, Wiley Eastern Ltd., 1979.
2. P.K. Gupta & D.S. Hira, *Operations Research-An Introduction*. S. Chand & Sons., 1976.
3. N.S. Kambo, *Mathematical Programming Techniques*, Affiliated East-West Press Pvt. Ltd., 2008.
4. M.S. Bazara, J.J. Jarvis, & H.D. Sherali, *Linear Programming and Network Flows*, Wiley, 2004.
5. S.J. Chandra & A. Mehra, *Numerical Optimization with Applications*, Narosa Publishing,2009
6. S.I., Gass, *Linear Programming- Methods and Applications*, Dover Publishers,2003.
7. A. Ravindran, D.T. Phillips & J.J. Solberg, *Operations Research- Principles and Practice*, Wiley India (P.) Ltd. (2005)

8. P.R. Thie & G.E. Keough, *An Introduction to Linear Programming and Game Theory*, John Wiley & Sons (2008).
9. A.T. Hamdy, *Operation Research: An Introduction*, Prentice-Hall of India Pvt. Ltd., 2002.

M.Sc. (Mathematics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	IV
Course Code	Course Title		Course Type
MAT442	**WAVELETS (II)**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The course aims to equip students with the knowledge and skills required to work with wavelets, frames, and discrete transforms in various applications, including signal processing, image compression, and data analysis. It prepares them to apply advanced wavelet-based techniques to efficiently and effectively solve real-world problems.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Demonstrate a comprehensive understanding of the foundational characterizations in the theory of wavelets, including the basic equations and their practical applications in areas such as signal processing and data analysis.	**U**
2	Examine characterizations of Multiresolution Analysis (MRA) wavelets, low-pass filters, and scaling functions. Discuss the concept of non-existence of smooth wavelets in $H^2(R)$ and its implications in signal processing and wavelet theory.	**An**
3	Apply the principles and techniques associated with frames in wavelet theory, including the reconstruction formula and the Balian-Low theorem for frames. Examine the process of generating frames from translations and dilations and the concept of smooth frames for $H^2(R)$.	**Ap**
4	Apply the knowledge of discrete transforms, including the discrete Fourier transform and the discrete cosine transform, along with their corresponding fast algorithms.	**Ap**
5	Apply the discrete version of local sine and cosine bases to decomposition and reconstruction algorithms for wavelets, to process and transform data using wavelet techniques in practical applications.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO2	3	3	3	-	2	-	2	1	-	2	2	3	1	2	-	-
CO3	3	3	3	-	2	-	2	1	-	2	2	3	1	2	-	-
CO4	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO5	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Characterizations in the theory of wavelets-The basic equations and some of its applications.	15	1
II	Characterizations of MRA wavelets, low-pass filters and scaling functions. Non- existence of smooth wavelets in $H^2(R)$.	15	2
III	Frames - The reconstruction formula and the Batian-Low theorem for frames. Frames from translations and dilations. Smooth frames for $H^2(R)$.	15	3
IV	Discrete transforms and algorithms-The discrete and the fast Fourier transforms. The discrete and the fast cosine transforms.	15	4
V	The discrete version of the local sine and cosine bases. Decomposition and reconstruction algorithms for wavelets.	15	5

Reference Books:

1. E. Hernandez & G.Weiss, *A First Course on Wavelets*, CRC Press, New York, 1996.
2. C.K. Chui, *An Introduction to Wavelets*, Academic Press, 1992.
3. I.Daubechies, *Ten Lectures on Wavelets*, CBS-NSF Regional Conferences in Applied Mathematics, 61, SIAM, 1992.
4. Y.Meyer, *Wavelets - Algorithms and Applications*, SIAM, 1993.
5. M.V. Wickerhauser, *Adapted Wavelet Analysis: From Theory to Software*, CRC Press, 1994.

M.Sc. (Mathematics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	IV
Course Code	Course Title		Course Type
MAT451	**PROGRAMMING IN C (WITH ANSI FEATURES) (II)**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3 (T) + 2 (P)=5	3	1	4

Maximum Marks	CIA	ESE
100	30	50 Theory + 20 Practical

Learning Objective (LO):

The objectives of this course are to provide students with the essential skills and knowledge required to write C programs involving storage management, pointer operations, function implementation, data organization, and input/output operations. The course aims to prepare students to confidently tackle real-world programming tasks using the C programming language.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to:	CL
1	Explainzx storage classes, distinguish fixed and automatic duration variables. Illustrate the concept of scope in variable declarations, use of global variables, the register specifier.	**U**
2	Perform pointer arithmetic, access array through pointers, pass pointers and arrays as function arguments, implement sorting algorithms, work with strings, create arrays of pointers, and manage pointers to pointers.	**Ap**
3	Explore functions, pass arguments, declare and call functions, work with pointers to functions, and implement recursion. Utilize Preprocessor, including macro substitution, conditional compilation.	**Ap**
4	Design and manage complex data structures using structures and union. Implement dynamically allocate memory for data structures, linked lists, and work with enum declarations.	**An**
5	Execute input and output operations, including streams, buffering. Utilize the <stdio.h> header file. Illustrate error handling, opening and closing files, reading and writing data to files.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	-	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-
CO2	-	1	2	3	3	3	2	2	2	1	2	1	1	-	3	-
CO3	-	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-
CO4	-	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-
CO5	-	1	2	3	3	3	2	2	2	2	2	1	1	-	3	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Storage Classes-Fixed vs. Automatic Duration. Scope. Global variables. The register Specifier. ANSI rules for the syntax and Semantics of the storage-class keywords.	8	1
II	Pointers-Pointer Arithmetic. Passing Pointers as Function Arguments. Accessing Array Elements through Pointers. Passing Arrays as Function Arguments. Sorting Algorithms. Strings. Multidimensional Arrays. Arrays of Pointers. Pointers to Pointers.	10	2
III	Functions-Passing Arguments. Declarations and Calls. Pointers to Functions. Recursion. The main Function. Complex Declarations. The C Preprocessor-Macro Substitution. Conditional Compilation. Include Facility. Line Control.	9	3
IV	Structures and Unions-Structures. Dynamic Memory Allocation. Linked Lists. Unions, enum Declarations.	10	4
V	Input and Output-Streams, Buffering. The <Stdio.h> Header File. Error Handling. Opening and Closing a File. Reading and Writing Data. Selecting an I/O Method. Unbuffered I/O Random Access. The standard library for Input/Output.	8	5

Books Recommended:

1. Y.Kanetkar, Let Us C, BPB Publications, 2016.

Reference Books:

1. P.A. Darnell & P.E. Margolis, C: A Software Engineering Approach, Narosa Publishing House,1993.
2. S.P.Harkison & G.L.Steele Jr., C: A Reference Manual, Prentice Hall, 1984.
3. B.W. Kernighan & D.M. Ritchie, The C Programme Language, (ANSI Features), Prentice Hall 1989.

M.Sc. (Mathematics) Semester-IV

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	IV
Course Code	Course Title		Course Type
MAT452	**GRAPH THEORY (II)**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--
Maximum Marks	CIA		ESE
100	30		70

Learning Objective (LO):

The course aims to equip students with the knowledge and skills necessary to explore Ramsey Theory, groups and their applications in graph theory, polynomials and graph enumeration techniques, as well as digraphs and network analysis.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Apply Ramsey theory to analyze perfectness-preserving operations, forbidden subgraph orientations, Ramsey numbers, and Ramsey graphs.	**Ap**
2	Apply group theory concepts within the context of graph theory, including permutation groups, automorphism groups, and graphs with given groups.	**Ap**
3	Utilize polynomial methods for graph enumeration, focusing on color, chromatic, and bivariate coloring polynomials. Implement polynomial techniques to enumerate and analyze various graph structures.	**An**
4	Analyze chromatic properties of graphs, including co-chromatic (co-dichromatic) graphs and chromatically unique graphs.	**An**
5	Describe digraphs, including different types of connectedness and flows in networks. Illustrate Menger's and Konig's Theorems.	**U**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO2	3	3	3	-	2	-	2	1	-	2	2	3	1	2	-	-
CO3	3	3	3	-	3	-	2	1	-	2	2	3	1	2	-	-
CO4	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-
CO5	3	3	3	-	1	-	2	1	-	2	2	3	1	2	-	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	Ramsey Theory: Perfectness-preserving operations, Forbidden Subgraph orientations, Ramsey numbers and Ramsey graphs.	15	1
II	Groups: Permutation groups, The automorphism group, graphs with given group, symmetry concepts, pseudo-similarity and stability, spectral studies of the Automorphism group.	15	2
III	Polynomials and Graph Enumeration: The colour polynomials, The chromatic polynomial, The bivariate colouring polynomials.	15	3
IV	Graph Enumeration: Co-chromatic (co-dichromatic) graphs and chromatically unique graphs, Graph Enumeration.	15	4
V	Digraphs & Networks: Digraphs, Types of connectedness, Flows in Networks, Menger's and Konig's Theorem, Degree sequences.	15	5

Books Recommended:

1. K.R.Parthasarathy, *Basic graph theory*, Tata Mcgraw Hill Publishing Company Limited , 1994.

Reference Books:

1. R.J.Wilson, *Introduction to Graph Theory*, Longman Harlow, 1985.
2. J. Clark, D.A. Holton, *A First Look at Graph Theory*, World Scientific Singapore, 1991.
3. F. Hararary, *Graph Theory*, Narosa, New Delhi, 1995.
4. R. Gould, *Graph Theory*, The Benjamin/Cummins Publ. Company, 1988.
5. N. Deo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice-Hall of India, 2002.

M.Sc. (Mathematics) Semester-IV

(Offered to PG students of SoS in Mathematics only)

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	IV
Course Code	Course Title		Course Type
MAT453	**CRYPTOGRAPHY**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
5	5	1	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The course aims to provide students with a deep understanding of various cryptographic techniques and their practical applications, enabling them to design secure communication systems and authenticate digital information effectively.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Apply classical cryptographic techniques such as the Shift Cipher, Substitution Cipher, Affine Cipher, Vigenere Cipher, to encrypt and decrypt messages.	**Ap**
2	Analyze the theoretical foundations of cryptography, including Shannon's Theory of Perfect Secrecy, and assess the security levels of cryptographic algorithms.	**An**
3	Compare public key cryptography, including the RSA Cryptosystem, Diffie-Hellman Key Exchange Protocol, and ElGamal Cryptosystem. Estimate the security implications of these cryptographic systems and protocols.	**U**
4	Examine the security of hash functions, including SHA-1 and MD-5. Assess the use of message authentication codes (MACs) in ensuring data authenticity and integrity.	**An**
5	Apply digital signature techniques, including RSA Signature, ElGamal Signature, and the Digital Signature Algorithm (DSA), to verify the authenticity of messages and documents.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

CO-PO/PSO Mapping for the course:

PO / CO	POs											PSO				
	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
CO1	3	2	3	2	3	3	2	2	1	3	2	2	3	3	1	-
CO2	3	2	3	2	3	3	2	2	1	3	2	2	3	3	1	-
CO3	3	2	3	2	3	3	2	2	1	3	2	2	3	3	1	-
CO4	3	2	3	2	3	3	2	2	1	3	2	2	3	3	1	-
CO5	3	2	3	2	3	3	2	2	1	3	2	2	3	3	1	-

"3" – Strong; "2" – Moderate; "1"- Low; "-" No Correlation

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	The Shift Cipher, The Substitution Cipher, The Affine Cipher, The Vigenere Cipher, The Hill Cipher, The Permutation Cipher, Stream & Block ciphers.	15	1
II	Shannon's Theory of Perfect Secrecy, Vernam One Time Pad, Random Numbers, Mode of operations in block cipher, the Data Encryption Standard (DES), Feistel Ciphers, the Advanced Encryption Standard(AES), Prime Number Generation, Fermat Test, Miller Rabin Test.	14	2
III	Public Key Cryptography, RSA Cryptosystem, Factoring problem, Rabin Cryptosystem, Quadratic Residue Problem, Diffie-Hellman (DH) Key Exchange Protocol, Discrete Logarithm Problem (DLP), ElGamal Cryptosystem, Elliptic Curve, Elliptic Curve Cryptosystem (ECC),	16	3
IV	Hash and Compression Functions, Security of Hash Functions, Iterated Hash Functions, SHA-1, MD-5, Message Authentication Codes.	15	4
V	Digital Signature, RSA Signature, ElGamal Signature, Digital Signature Algorithm (DSA), ECDSA. Identification and Authentication.	15	5

Books Recommended:

1. J Buchmann, *Introduction to Cryptography*, Springer (India), 2004
2. D R Stinson, *Cryptography: Theory and Practice*. CRC Press, 2000.

Reference Books:

1. S. Padhye, R.A. Sahu & V. Saraswat, *Introduction to Cryptography*, CRC Press, 2018
2. B. Forouzan, *Cryptography and Network security*, Tata McGraw Hill, 2011
3. W. Mao, *Modern Cryptography: Theory and Practice*, Pearson Education, 2004
4. Thomas Koshy, Elementary Number Theory with Applications, Elsevier, 2007.

M.Sc. (Mathematics) Semester-II

(Offered to PG students of other Departments/SoS only)

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	II
Course Code	Course Title		Course Type
MAT610	**Elementary Mathematics for Social Sciences**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3	3	--	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The course aims to equip students with the knowledge and skills necessary to explore fundamental algebraic concepts, functions, exponential and logarithmic functions, as well as systems of linear equations and matrices.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Find factors and roots of polynomials, simplify rational expressions, solve linear and quadratic equations.	**Ap**
2	Interpret and manipulate graphs and equations, Illustrate linear equations and inequalities.	**U**
3	Apply a variety of functions, including linear, quadratic, polynomial, and rational functions, to solve problems.	**Ap**
4	Explain and manipulate exponential and logarithmic functions, solve equations involving these functions.	**Ap**
5	Solve system of linear equations, perform matrix operations, including products and inverses. Apply matrices to solve system of equations.	**An**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	**Algebra and Equations:** The Real Numbers, Polynomials, Factoring, Rational Expressions, Exponents and Radicals, First Degree Equations, Quadratic Equations.	9	1
II	**Graphs, Lines, and Inequalities** Graphs, Equations of Lines, Linear Models, Linear Inequalities, Polynomial and Rational Inequalities.	9	2
III	**Functions and Graphs** Functions, Graphs of Functions, Applications of Linear Functions, Quadratic Function and Applications, Polynomial Functions, Rational Functions.	9	3
IV	**Exponential and Logarithmic Functions** Exponential Functions, Applications of Exponential Functions, Logarithmic Functions, Logarithmic and Exponential Equations.	9	4
V	**Systems of Linear Equations and Matrices** Systems of Two Linear Equations in Two Variables, Larger Systems of Linear Equations. Applications of Linear Equations, Basic Matrix Operations, Matrix Products and Inverses, Applications of Matrices.	9	5

Books Recommended:

1. M.L. Lial, T.W. Hungerford, J.P. Holcomb, B. Mullins: *Mathematics with Applications in the Management*, *Natural and Social Sciences*, 12th ed, Pearson, 2018.

M.Sc. (Mathematics) Semester-III

(Offered to PG students of other Departments/SoS only)

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT620	**Mathematics for Social Sciences**		Elective
Credit	Hours Per Week (L-T-P)		
	L	T	P
3	3	--	--

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The course objective is to provide students understanding and practical application of advanced mathematical concepts, including linear programming techniques, sets, probability theory, limits, derivatives, and integrals.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Solve problem related to linear inequalities, linear programming, and the simplex method for maximization, minimization, duality, and nonstandard problems.	**Ap**
2	Analyze and apply principles of set theory, Venn diagrams, contingency tables, and probability concepts, including conditional probability and Bayes' formula.	**An**
3	Apply the principles of limits, derivatives, and continuity, and employ various techniques, including the chain rule, to compute derivatives of a wide range of functions.	**Ap**
4	Apply the concepts of derivatives to optimization problems, implicit differentiation, related rates, and curve sketching.	**Ap**
5	Describe integral as antiderivative, evaluate integration by substitution, definite integrals. Explain and apply Fundamental Theorem of Calculus, solve differential equations.	**Ap**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

Detailed Syllabus:

Unit No.	Topics	No. of Lectures	CO No.
I	**Linear Programming:** Graphing Linear Inequalities in Two Variables, Linear Programming: The Graphical Method, Applications of Linear Programming, The Simplex Method: Maximization, Maximization Application, The Simplex Method: Duality and Minimization, The Simplex Method: Nonstandard Problems	9	1
II	**Sets and Probability:** Sets, Applications of Venn Diagrams and Contingency Tables, Introduction to Probability, Basic concepts of Probability, Conditional Probability and Independent Events, Bayes' Formula.	9	2
III	**Differential Calculus:** Limits, One-Sided Limits and Limits Involving Infinity, Rates of Change, Tangent Lines and Derivatives, Techniques for Finding Derivatives, Derivatives of Products and Quotients, The Chain Rule, Derivatives of Exponential and Logarithmic Functions, Continuity and Differentiability.	9	3
IV	**Applications of the Derivative:** Derivatives and Graphs, The Second Derivative, Optimization Applications, Implicit Differentiation, Related Rates, Curve Sketching.	9	4
V	**Integral Calculus:** Antiderivatives, Integration by Substitution, Area and the Definite Integral, The Fundamental Theorem of Calculus, Applications of Integrals, Differential Equations.	9	5

Books Recommended:

1. M.L.Lial,. T.W.Hungerford, J.P.Holcomb, B.Mullins: *Mathematics with Applications in the Management*, *Natural and Social Sciences*, 12th ed, Pearson, 2018.

M.Sc. (Mathematics) Semester-I

(Offered to PG students of SoS in Mathematics only)

Program	Subject	Year	Semester
M.Sc.	Mathematics	1	I
Course Code	Course Title		Course Type
MAT710	**Typesetting in LATEX**		Value Added
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	--	--	4

Maximum Marks	CIA	ESE
100	30	70

Learning Objective (LO):

The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting and beamer presentation.

Course Outcomes (CO):

CO No.	Expected Course Outcomes At the end of the course, the students will be able to :	CL
1	Create and typeset a mathematical document using LaTeX document.	**Ap**
2	Make various types of lists and tables in a document using LaTex.	**Ap**
3	Typeset and format equations using various types of environments, such as equations, align, gather etc., Define and use macros.	**Ap**
4	Insert and format figures in a document including its position, orientation and size. Make presentation using beamer.	**An**

CL: Cognitive Levels (**R**-Remember; **U**-Understanding; **Ap**-Apply; **An**-Analyze; **E**-Evaluate; **C**-Create).

Detailed Syllabus:

Unit No.	Topics	No. of Contact Hours	CO No.
I	**Getting Started with LaTeX, Page Layout and Style:** Introduction to TeX and LaTeX, Overview, Fonts Selection, Formatting text, Standard Page Layout, Formatting Page Layout, Increasing the Height of a Page, Page Style, Running Header and Footer, Page Breaking and Adjustment, Page Numbering. (Chapter 1-5).	6	1
II	**Listing and Tabbing Texts, Table Preparation:** Listing Texts, Tabbing Texts Through the tabbing Environment. Table Through the tabular, Table Through the tabularx Environment, Vertical Positioning of Tables, Sideways (Rotated) Texts in Tables, Adjusting Column Width in Tables, Additional Provisions for Customizing	6	2

	Columns of Tables, Merging Rows and Columns of Tables, Table Wrapped by Texts, Table with Colored Background. (Chapter 6-7).		
III	**Equation Writing and User-Defined Macros:** Basic Mathematical Notations and Delimiters, Mathematical Operators, Mathematical Expressions in Text, Simple Equations, Array of Equations, Left Aligning an Equation, Sub-numbering a Set of Equations, Texts and Blank Space in Math-Mode, Conditional Expression, Evaluation of Functional Values, Splitting an Equation into Multiple Lines, Vector and Matrix, Overlining and Underlining, Stacking Terms, Side-by-Side Equations. User-Defined Macros, Defining New Commands, Redefining Existing Commands, Defining New Environments, Redefining Existing Environments. (Chapter 11-13).	6	3
IV	**Figure Insertion and Slide Preparation:** Commands and Environment for Inserting, Inserting a Simple Figure, Side-by-Side Figures, Sub-numbering a Group of Figures, Figure Wrapped by Texts, Rotated Figure, Mathematical Notations in Figures, Figures in Tables, Figures in Multi-column Documents, Changing Printing Format of Figures, Figures at the End of a Document, Editing LATEX Input File Involving Many Figures, Frames in Presentation, Sectional Units in Presentation, Presentation Structure, Appearance of a Presentation (BEAMER Themes), Frame Customization, Piece-Wise Presentation (BEAMER Overlays), Environments in BEAMER Class, Table and Figure in Presentation, dividing a Frame Column-Wise, Repeating Slides in Presentation, Jumping (Hyperlink) to Other Slides. (Chapter 9, 21 & 22).	6	4

Books Recommended:

Dilip Datta, *LATEX in 24 Hours (A Practical Guide for Scientific Writing)*, Springer (2017).

M.Sc. (Mathematics) Semester-III

(Offered to PG students of SoS in Mathematics only)

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT810	**Indian Knowledge System (IKS)-Concepts and Mathematics Tradition**		IKS
Credit	Hours Per Week (L-T-P)		
	L	T	P
2	2	--	--
Maximum Marks	CIA	ESE	
100	30	70	

Learning Objective (LO):

The course aims to:

- Sensitize the students about context in which they are embedded, i.e., Indian culture and civilisation including its Knowledge System and Tradition.
- Provide information about great mathematicians and astronomers who given significant contribution in Indian mathematics and astronomy.
- Help students to trace, identify, practice and develop the significant Indian mathematic.

Detailed Syllabus:

Unit No.	Topics	No. of Lectures
I	Indian Knowledge System (IKS) – An Introduction: What is IKS? Why do we need IKS? Organization of IKS. Historicity of IKS Some salient aspects of IKS.	6
II	The Vedic Corpus: Introduction to Vedas. A synopsis of the four Vedas. Sub-classification of Vedas. Messages in Vedas. Introduction to Vedāṅgas. Prologue on Śikṣā and Vyākaraṇa. Basics of Nirukta and Chandas. Introduction to Kalpa and Jyotiṣa. Vedic Life: A Distinctive Features.	6
III	Wisdom through the Ages: Gateways of ancestral wisdoms. Introduction to Purāṇa. The Purāṇic repository. Issues of interest in Purāṇas. Introduction to Itihāsas. Key messages in Itihāsas. Wisdom through Nīti-śāstras. Wisdom through Subhāṣita.	6
IV	Number Systems and Units of Measurement: Number systems in India – Historical evidence. Salient aspects of Indian Mathematics. Bhūta-Saṃkhyā system. Kaṭapayādi system. Measurements for time, distance, and weight. Piṅgala and the binary system.	6
V	Indian Mathematics Tradition: Introduction to Indian Mathematics. Unique aspects of Indian Mathematics. Indian Mathematicians and their Contributions. Algebra, Geometry, Trigonometry. Binary mathematics and combinatorial problems in Chandaḥ Śāstra. Magic squares in India.	6

Books Recommended:

B. Mahadevan, Vinayak Rajat Bhat, R.N. Nagendra Pavana, Introduction to Indian Knowledge System: Concepts and Applications, PHI Learning Pvt. Ltd., 2022

Reference Books:

1. K. Kapur A.K. Singh (Eds), Indian Knowledge Systems, Vol. 1 & 2. D.K. Printworld Pvt. Ltd., 2005
2. शशिबाला, ओम विकास, अशोक प्रधान (संपादक), भारती विद्या सार-1, भारतीय विद्या भवन, 2018.
3. S. B. Rao, Indian Mathematics and Astronomy: Some Landmarks (Revised Third Edition), Bhartiya Vidhya Bhavan, 2012,
4. G.G.Josheph, Indian Mathematics: Engaging with the World from Ancient to Modern Times, speaking Tiger, 2016
5. B.S. Yadav, Ancient Indian Leaps into Mathematics, Birkausher Publication, 2010
6. Dharampal, Indian Science and Technology in the Eighteenth Century, Other India Press, 2000
7. Dharampal, The Beautiful Tree: Indigenous Indian Education in the Eighteenth Century, Other India Press, 2000

School of Studies in Mathematics,
Pt.Ravishankar Shukla University Raipur

Syllabus

M.Sc. Mathematics Entrance Examination
(Semester System)

Admission Session: 2024-25 onwards

Approved by:	Board of Studies	Academic Council
Date:		

CALCULUS:

$\varepsilon - \delta$ definition of the limit of a function. Basic properties of limits. Continuous functions and classification of discontinuties. Differentiability. Successive differentiation. Leibnitz theorem. Maclaurin and Taylor series expansions. Integration of transcendental functions. Reduction formulae. Definite integrals. Quadrature. Rectification. Volumes and surfaces of solids of revolution.

Definition of a sequence. Theorems on limits of sequences. Bounded and monotonic sequences. Cauchy's convergence criterion. Series of non-negative terms. Comparison tests, Cauchy's integral test, Ratio tests, Raabe's, logarithmic, de Morgan and Bertrand's tests. Alternating series, Leibnitz's theorem. Absolute and conditional convergence. Continuity, Sequential continuity, Properties of continuous functions, Uniform continuity, Chain rule of differentiability, Mean value theorems and their geometrical interpretations. Darboux's intermediate value theorem for derivatives, Taylor's theorem with various forms of remainders. Limit and continuity of functions of two variables. Partial differentiation. Change of variables. Euler's theorem on homogeneous functions. Taylor's theorem for functions of two variables. Jacobians. Envelopes, evolutes. Maxima, minima and saddle points of functions of two variables. Lagrange's multiplier method.

ALGEBRA:

Elementary operations on matrices, Inverse of a matrix. Linear independence of row and column matrices, Row rank, column rank and rank of a matrix. Equivalence of column and row ranks. Eigenvalues, eigenvectors and the characteristic equations of a matrix. Cayley Hamilton theorem and its use in finding inverse of a matrix. Application of matrices to a system of linear (both homogeneous and nonhomogeneous) equations. Theorems on consistency of a system of linear equations.

Mappings, Equivalence relations and partitions. Congruence modulo n. Definition of a group with examples and simple properties. Subgroups, generation of groups, cyclic groups, coset decomposition, Lagrange's theorem and its consequences. Fermat's and Euler's theorems. Normal subgroups. Quotient group, Permutation groups. Even and odd permutations. The alternating groups An. Cayley's theorem. Homomorphism and Isomorphism the fundamental theorems of homomorphism. Automorphisms, inner automorphism. Automorphism groups and their computations, Conjugacy relation, Normaliser, Counting principle and the class equation of a finite group. Center for Group of prime-order, Abelianizing of a group and its universal property. Sylow's theorems, Sylow subgroup, Structure theorem for finite Abelian groups. Ring theory-Ring homomorphism. Ideals and quotient rings. Field of quotients of an integral domain, Euclidean rings, polynomial rings, Polynomials over the rational field. The Eisenstien criterion, polynomial rings over commutative rings, Unique factorization domain. R unique factorisation domain implies so is R[x1, x2 ..... xn]. Modules, Submodules, Quotient modules, Homomorphism and Isomorphism theorems. Definition and examples of vector spaces. Subspaces. Sum and direct sum of subspaces. Linear span, linear dependence, independence and their basic properties. Basis. Finite dimensional vector spaces. Existence theorem for bases. Invariance of the number of elements of a basis set. Dimension. Existence of complementary subspace of a subspace of a finite dimensional vector space. Dimension of sums of subspaces. Quotient space and its dimension.

Linear transformations and their representation as matrices. The Algebra of linear transformations. The rank nullity theorem. Change of basis. Dual space. Bidual space and natural isomorphism. Adjoint of a linear transformation. Eigenvalues and eigenvectors of a linear transformation. Diagonalisation. Annihilator of a subspace. Bilinear, Quadratic and Hermitian forms. Inner Product Spaces-Cauchy-Schwarz inequality. Orthogonal vectors. Orthogonal Complements. Orthonormal sets and bases. Bessel's inequality for finite dimensional spaces. Gram-Schmidt Orthogonalization process.

DIFFERENTIAL EQUATIONS:

Degree an order of a differential equation. Equations reducible to the linear form. Exact differential equations. First order higher degree equations solvable for x, y, p. Clairaut's form and singular solutions. Geometrical meaning of a differential equation. Orthogonal trajectories. Linear differential equations with constant coefficients. Homogeneous linear ordinary differential equations. Linear differential equations of second order. Transformation of the equation by changing the dependent variable/the independent variable. Method of variation of parameters. Ordinary simultaneous differential equations.

Laplace Transformation- Linearity of the Laplace transformation, Existence theorem for Laplace transforms, Laplace transforms of derivatives and integrals, Shifting theorems. Differentiation and integration of transforms. Convolution theorem. Solution of integral equations and systems of differential equations using the Laplace transformation. Partial differential equations of the first order. Lagrange's solution, some special types of equations which can be solved easily by methods other than the general method, Charpit's general method of solution. Partial differential equations of second and higher orders, Classification of linear partial differential equations of second order, Homogeneous and non-homogeneous equations with constant coefficients, Partial differential equations reducible to equations with constant coefficients, Monge's methods.

ANALYSIS:

Series of arbitrary terms. Convergence, divergence and oscillation. Abel's and Dirichlet's test. Multiplication of series. Double series. Partial derivation and differentiability of real-valued functions of two variables. Schwarz and Young's theorem. Implicit function theorem. Fourier series. Fourier expansion of piecewise monotonic functions. Riemann integral. Intergrability of continuous and monotonic functions. The fundamental theorem of integral calculus. Mean value theorems of integral calculus. Improper integrals and their convergence. Comparison tests. Abel's and Dirichlet' tests. Frullani's integral. Integral as a function of a parameter. Continuity, derivability and integrability of an integral of a function of a parameter.

Complex numbers as ordered pairs. Geometric representation of complex numbers. Stereographic projection. Continuity and differentiability of complex functions. Analytic functions. Cauchy-Riemann equations. Harmonic functions. Elementary functions. Mapping by elementary functions. Mobius transformations. Fixed points, Cross ratio. Inverse points and critical mappings. Conformal mappings.

METRIC SPACES:

Definition and examples of metric spaces. Neighbourhoods, limit points, interior points, open and closed sets, closure and interior. Boundary points, Sub-space of a metric space. Cauchy sequences, completeness, Cantor's intersection theorem. Contraction principle, construction of real numbers as the completion of the incomplete metric space of rationals. Real numbers as a complete ordered field. Dense subsets. Baire Category theorem. Separable, second countable and first countable spaces. Continuous functions. Extension theorem. Uniform continuity, isometry and homeomorphism. Equivalent metrics. Compactness, sequential compactness. Totally bounded spaces. Finite intersection property. Continuous functions and compact sets, connectedness, components, continuous functions and connected sets.