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M.Sc. (Mathematics) Semester-III (July 2026-Dec 2026)

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

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CO-PO/PSO Mapping for the course:

CO \ PO	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. Lebesgue 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.

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Learning Objective (LO):

Course Outcomes (CO):

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

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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 (i) '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.

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M.Sc. (Mathematics) Semester-III (July 2026-Dec 2026)

Program	Subject	Year	Semester
M.Sc.	Mathematics	2	III
Course Code	Course Title		Course Type
MAT332	FUZZY SET THEORY & ITS APPLICATIONS (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 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	CL
	At the end of the course, the students will be able to :	
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).

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CO-PO/PSO Mapping for the course:

CO \ PO	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.



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M.Sc. (Mathematics) Semester-III (July 2026-Dec 2026)

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

CO \ PO	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).

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M.Sc. (Mathematics) Semester-III (July 2026-Dec 2026)

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

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CO-PO/PSO Mapping for the course:

CO \ PO	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, Homeomorphism, 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. Harary, *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.

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