KANNUR UNIVERSITY

(Abstract)

M Sc Mathematics Programme in the Department of Mathematical Sciences, Mangattuparamba Campus -Revised Scheme (Distribution of credits of Four semesters) & Syllabus (1st Semester Only) - Approved- Implemented w.e f 2023 admission- Orders Issued

ACADEMIC C SECTION

ACAD C/ACAD C3/26618/2023 Dated: 26.12.2023

Read:-1. UO No ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
2. Circular No dated ACAD C/ ACAD C3/22373/2019 dated 12/09/2023
3. Email dated 18/12/2023 from the Head, Dept of Mathematical Sciences, Mangattuparamba Campus
4. Minutes of the meeting of the Department Council dated 14/09/2023

ORDER

1. The revised Regulations for Post Graduate Programmes under Choice Based Credit and Semester System in the University Teaching Departments/ Schools were implemented w.e.f 2023 admissions vide paper read 1 above
2. As per paper read 2 above, Heads of all Teaching Departments were requested to submit the revised Syllabus in accordance with the approved Regulations along with a copy of the Department Council Minutes.
3. As per paper read 3 above, the Head, Department of Mathematical Sciences, Mangattuparamba Campus submitted the scheme (Distribution of credits of Four Semesters) and the Syllabus (1^{st} Semester Only) of M.Sc Mathematics Programme to be implemented in the University Teaching Department w.e.f 2023 admissions, verified by the external expert.
4. Department Council vide the paper read 4 above approved the aforementioned scheme and syllabus of M.Sc Mathematics Programme to be implemented in the Dept. of Mathematical Sciences, Mangattuparamba Campus of the University w.e.f.2023 admission.
5. The Vice Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under section 11(1), Chapter III of Kannur University Act 1996, ***approved the Scheme (Distribution of credits of Four Semesters) & Syllabus (1^{st} Semester Only) of M.Sc*** Mathematics ***Programme and accorded sanction to implement the same in the Department of Mathematical Sciences, Mangattuparamba Campus w.e.f 2023 admissions, subject to reporting to the Academic Council***
6. The Scheme (Credit distribution of Four Semesters) and Syllabus (1^{st} Semester Only) of M.Sc Mathematics Programme under CBCSS implemented in the Department of Mathematical Sciences, Mangattuparamba Campus with effect from 2023 admission, is appended and uploaded in the University website (www.kannuruniversity.ac.in)
7. Orders are issued accordingly.

Sd/-
Narayanadas K
DEPUTY REGISTRAR (ACAD)
For REGISTRAR

To: 1. Head, Department of Mathematical Sciences, Mangattuparamba Campus
2. Convenor, Curriculum Committee

Copy To: 1. PS to VC/ PA to PVC/ PA to R
2. To Examination Branch (through PA to CE)
3. EP IV/ EXC I
4. Computer Programmer
5. Web Manager (to publish on the website)
6. SF/DF/FC

KANNUR UNIVERSITY CIVIL STATION P.O. KANNUR Pin-670 002 THAVAKKARA

Forwarded / By Order
SECTION OFFICER

KANNUR UNIVERSITY

(Abstract)

M. Sc Mathematics Programme in the Dept of Mathematical Sciences, Mangattuparamba Campus of Kannur University - Scheme & Syllabus of II, III & IV Semesters - Approved - Implemented w. e. f 2023 admission - Orders Issued.

ACADEMIC C SECTION

ACAD C/ACAD C3/26618/2023 Dated: 24.04.2024

Read:-1. U.Os No ACAD C/ACAD C3/22373/2019 dated 12/09/2023, 08/11/2023 & 16/02/2023

2. U.O of even number dated 26/12/2023

3. Circulars of No ACAD C/ACAD C3/22373/2019 dated 01/02/2024 & 12/03/2024

4. Email dated 04/04/2024 from the Head , Dept of Mathematical Sciences, Mangattuparamba Campus

5. Minutes of the meeting of the Department Council dated 20/03/2024

6. Orders of Vice Chancellor in file of even No. dated 24-4-2024

ORDER

1. The revised Regulations for PG Programmes under CBCSS in the University Teaching Depts/ Schools were implemented w. e. f 2023 admissions vide paper read (1) above.

2. As per paper read (2) above, Revised Distribution of Credits of Four Semesters, Scheme & Syllabus (I Semester Only) of M. Sc Mathematics Programme was approved and implemented in the Dept of Mathematical Sciences, Mangattuparamba Campus w. e. f 2023 admission.

3. As per paper read (3) above, Heads of all Teaching Depts who had not submitted the syllabi in full, were requested to submit the syllabi of the remaining semesters in accordance with the approved Regulations and along with a copy of the Department Council Minutes.

4. As per paper read (4) above, the Head, Dept of Mathematical Sciences submitted the Scheme & Syllabus (II, III & IV Semesters) of M. Sc Mathematics Programme to be implemented in the University Teaching Dept w.e.f 2023 admission.

5. Dept Council vide paper read (5) above, approved the aforementioned Scheme & Syllabus of M Sc Mathematics Programme to be implemented in the Dept of Mathematical Sciences w.e.f 2023 admission .

6. The Vice Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under Section 11(1), Chapter III of Kannur University Act 1996, ***approved the Scheme & Syllabus (II, III & IV Semesters) of M. Sc Mathematics Programme and accorded sanction to implement the same in the Dept of Mathematical Sciences, Mangattuparamba Campus w. e. f 2023 admission, subject to report to the Academic Council***.

7. The Scheme & Syllabus (II nd, III rd& IV th Semesters) of M. Sc Mathematics Programme under CBCSS, implemented in the Dept of Mathematical Sciences w. e. f 2023 admission, is appended and uploaded in the University website (www.kannuruniversity.ac.in).

8. Orders are issued accordingly.

Sd/-

Narayanadas K

DEPUTY REGISTRAR (ACAD)

For REGISTRAR

To: 1. Head, Dept of Mathematical Sciences, Mangattuparamba Campus

2. Convenor, Curriculum Committee

Copy To: 1. PS to VC/ PA to R

2. PA to CE (to circulate among the sections of the Examination Branch concerned)

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KANNUR UNIVERSITY CIVIL STATION P.O. KANNUR Pin-670 002 THAVAKKARA

Forwarded / By Order

SECTION OFFICER

KANNUR UNIVERSITY

M.Sc. MATHEMATICS

SCHEME & SYLLABUS

(Under Choice Based Credit & Semester System)

2023 admission onwards

DEPARTMENT OF MATHEMATICAL SCIENCES
Kannur University
Mangattuparamba Campus,

KANNUR UNIVERSITY

Learning Outcome Based Curriculum Frame Work and Programme Structure.

Post Graduate Programme in Mathematics

The M.Sc. Mathematics course is a comprehensive two-year program designed to provide students with an advanced understanding of various branches of mathematics divided into four semesters, each focusing on different areas of pure mathematical theories.

DURATION: 2 Years (4 semesters)

ELIGIBILITIES:

- B.Sc. Degree in Mathematics with 50% marks

ADMISSION:
- The selection of the candidate is based on the marks secured in the Degree Course/Admission test.

- The admission test will cover basic mathematics at the undergraduate level.

Objective of the Course

1.: Advanced knowledge and understanding: Students will develop a thorough understanding of the foundational concepts, principles, and theories within each subject area. They will gain a deep knowledge of algebraic structures, linear transformations, differential equations, real analysis , topology, measure theory, complex analysis, functional analysis, and differential geometry.

2: Mathematical reasoning and problem-solving skills: Students will enhance their ability to apply rigorous mathematical reasoning and critical thinking skills to solve complex problems. They will learn to analyze mathematical structures, formulate hypotheses, and construct logical arguments to prove theorems and solve mathematical problems across various areas of pure mathematics.

3. **:** Advanced mathematical proof writing: Students will develop strong skills in constructing rigorous mathematical proofs. They will also improve their ability to present complex mathematical arguments in a clear and concise manner.

4. **:** Research skills and independent study: Each course may provide opportunities for students to engage in independent research projects and develop research skills. Students will learn to conduct literature reviews, identify research gaps, formulate research questions, and apply appropriate mathematical methods to investigate and contribute to the field of pure mathematics.

5.: Effective mathematical communication: Students will enhance their ability to communicate complex mathematical concepts and results effectively. They will learn to present mathematical ideas, findings, and proofs in both written and oral forms, using appropriate mathematical language and notation.

6 : Preparation for further study or career: An MSc Mathematics degree in pure mathematics can serve as a stepping stone for further academic pursuits, such as pursuing a Ph.D. in mathematics or related fields. It can also provide a solid foundation for careers in academia, research institutions, government agencies, or industries that require advanced mathematical skills and problem-solving abilities.

COURSE DETAILS:

A student must register for the required number of courses at the beginning of each semester. No students shall register for more than 24 credits and less than 16 credits per semester.

A total of 80 credits shall be the minimum for successful completion of the course in which a minimum of 60 credits for core course and 12 credits for electives are mandatory. Those who secure only minimum credit for core/ elective subjects has to supplement the deficiency for obtaining the minimum total credits required for successful completion of the program from the other divisions.

EVALUATION:

The proportion of the distribution of marks among the continuous evaluation and end semester examination shall be **40:60**.

Continuous Evaluation includes assignments, seminars, and written examination for each course. Weightage to the components of continuous evaluation shall be given for all theory papers of the course as follows:

Components of CE	Minimum Number	Weightage	Marks
Test paper	2	40	16
Assignments	1	20	08
Seminar & Viva	1	40	16

Test Paper: For each course there shall be at least two class tests during a semester.

Assignments: Each student shall be required to do one assignment for each course.

Seminar: Students are required to present a seminar on a selected topic in each paper. The evaluation of the seminar shall be done by the concerned teacher handling the course.

Attendance: Minimum attendance required for each paper shall be 75% of the total number of classes conducted for that semester. Those who secured the minimum requirement of attendance only be allowed to register/appear for End Semester Examination.Condonation of attendance to a maximum of 10 days in a semester subject to a maximum of two times during the whole period of the PG program may be granted by the university as per university rules.

Conduct of Examination:

The vice chancellor will approve the panel of examiners submitted by the Head of the Department. All the teachers of the Department will be the members of the Board of examiners with Head of the Department as the Chairperson. There shall be a minimum of two external examiners. The panel approved by the Vice-Chancellor will be entrusted with the setting of question papers, conduct and evaluation of examination.

Research Project:

The students have to complete a project during IV Semester under the guidance of a faculty in the department

KANNUR UNIVERSITY

DEPARTMENT OF MATHEMATICAL SCIENCES

VISION

Promote quality education and innovative research in mathematical sciences.

MISSION

Promote quality education and innovative research in mathematical sciences in Kerala, In Particular in North Kerala.

Programme Outcome (PO)

PO 1 : **Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.

PO2 : **Problem Solving:** Identify, formulate, conduct investigations, and find solutions to problems based on in-depth knowledge of relevant domains.

PO 3 : **Communication:** Speak, read, write and listen clearly in person and through electronic media in English/language of the discipline, and make meaning of the world by connecting people, ideas, books, media and technology.

PO 4 : **Responsible Citizenship:** Demonstrate empathetic social concern, and the ability to act with an informed awareness of issues.

PO 5 : **Ethics**: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

PO 6 : **Self-directed and Life-long Learning:** Acquire the ability to engage in independent and life-long learning in the broadest context socio- technological changes.

PO 7 : **Environmental Sustainability and Global Perspective:**
Develop an understanding of global standards to foster legal environment.
Learn and practice to critically analyze the legal issues from local, national and international concerns.

Proagramme Specific Outcome (PSO)

PSO1: To provide students with a deep and comprehensive understanding of advanced mathematical concepts and theories.

PSO2: To develop student’s research skills and provide them with the tools and techniques necessary to conduct independent mathematical research

PSO3: To enhance student’s problem-solving abilities through coursework, assignments, and projects, students are challenged to think critically, analyze complex problems, and develop effective strategies to solve mathematical challenges.

PSO4: To improve students' oral and written communication skills, enabling them to convey complex mathematical ideas clearly and concisely to both technical and non-technical audiences

PSO5: Encourage teamwork and collaboration among students through group projects, seminars, and discussions. This helps students develop their interpersonal and teamwork skills, which are essential in many professional settings.

PSO6: To instill a passion for lifelong learning in students and encourage them to stay updated with the latest advancements in mathematics through participation in conferences, workshops, and continued engagement with the mathematical community.

PSO7: The course can serve as a stepping stone to further study, such as pursuing a Ph.D. in Mathematics or a related field. Additionally, the degree equips students with analytical and problem-solving skills that are highly valued in various fields.

Distributions of Grades for the MSc. Mathematics Programme from 2023 onwards

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10** Total credits
	Discipline specific		**Electives**						
Sem	**Core courses (DSC)** (**4 credits** for each coursein semester 1,2,3)	**Electives (DSE-Discipline Specific Elective)**	Interdisciplinary/ Multidisciplinary Elective	AEC 2credits	SEC 2 credits	VAC/Mooc 2 credits	Internship/Field visit/Minor/Project/ Institutional /industrial visit 2 credits	Dissertation / Major project	
1	**MSMAT01DSC01 MSMAT01DSC02 MSMAT01DSC03 MSMAT01DSC04 MSMAT01DSC05 (Total 20 credits)**								**20**

2	**MSMAT02DSC06 MSMAT02DSC07 MSMAT03DSC08 MSMAT04DSC09 MSMAT05DSC10 (Total 20 credits)**			Offered by other departments	Offered by other departments				
	20 credits			**2 credits**	**2 credits**				**24**
3	**MSMAT03DSC11 MSMAT03DSC12** **(Total 8 credits)**	Choose one from **MSMAT03DSE 01 To MSMAT03DSE 03**	**Offered by other departments**						
	2x4 = 8 credits	**1x4 credits**	**1x4 credits**						**16**
4		**Choose four from MSMAT04DSE 04 to MSMAT04DSE 18**						**MSMAT04D SC13 (8 credits)**	
		4x4=16 credits						**8 credits**	**24**
	Total credits for MSc Mathematics Programme								**84**

Credits for MOOC is over and above the credit requirements

SCHEME

FIRST SEMESTER								
Course Code	**Title of Course**	**Contact Hours/Week**			**Marks**			
		L	**T/S**	**P**	**ESE**	**CE**	**Total**	**Credits**
DISCIPLINE SPECIFIC CORE COURSES								
MSMAT01DSC01	Algebra I	4	1		60	40	100	4
MSMAT01DSC02	Linear Algebra	4	1		60	40	100	4
MSMAT01DSC03	Ordinary Differential Equations	4	1		60	40	100	4
MSMAT01DSC04	Real Analysis	4	1		60	40	100	4
MSMAT01DSC05	Topology	4	1		60	40	100	4
	Total	**20**	**5**		**300**	**200**	**500**	**20**

Note: -L:Lecture ,T/S :Tutorial/Seminar, P :Practical ,ESE : End Semester Evaluation, CE Continuous Evaluation

FIRST SEMESTER M.Sc. MATHEMATICS PROGRAMME

DISCIPLINE SPECIFIC CORE COURSES

Course Code & Title	**MSMAT01DSC01-Algebra I**
Course Objectives	The Course aims To gain knowledge in basic group theory and ring theory which are essential for further study.

Module	Content	Module Outcome
I (15 Hours)	Direct products and finitely generated abelian groups. Homomorphisms, Factor groups. Factor group computations and simple groups. (Chapter 2 Section11 and Chapter 3 Sections 13-15 of text.)	Students are able to :learn about homomorphism and factor groups
II (15 Hours)	Group Action on a set Application of G-sets to counting, Sylow theorems, Applications of the Sylow theory. Free abelian groups. (Chapter 3 Section 16,17 and Chapter 7 Sections 36,37,38 of text.)	Able to get an understanding about Sylow's theorem and its applications
III (15 Hours)	Free groups. Group presentation. The Field of quotients of an integral domain. Ring of polynomials. (Chapter 7 Sections 39-40, Chapter 4 Sections 21,22 of text.)	Able to learn free groups and field of quotients. Also the definitions and properties of rings are introduced.
IV (15 Hours)	Factorization of polynomials over a field. Homomorphisms and factor rings. Prime and maximal ideals. (Chapter 4 Section 23; Chapter 5 Sections 26,27 of text.)	Able to learn about factorization of polynomials, and factor rings. Also the basic theory of ideals is introduced.
References	Text Books: J. B. Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn., 2003) Reference Books: 1. I.N. Herstein – Topics in Algebra- Wiley Eastern 2. J.A.Gallian – Contemporary Abstract Algebra 3. Hoffman & Kunze – Linear Algebra – Prentice Hall 4. M. Artin, Algebra, Prentice Hall, 1991 5. T.W.Hungerford: Algebra;Springer 1980 6. N.H.McCoy&Thomas R.Berger: Algebra-Groups,Ring and other topics:Allyn&Bacon	

Course Outcome	After successful completion of this course, student will be able to:
	CO1:To get a basic understanding of the important algebraic structure including groups, rings and fields. CO2: Knowledge of direct products and fundamental theorem of algebra facilitates students to understand the structure of finitely generated abelian groups. CO3: Understanding of homomorphisms, factor groups, group actions and subsequently the Sylow theorem enables the students to classify a large class of finite groups which are not necessarily abelian and understand their further structures. CO4: Knowledge of ring of polynomials, irreducibility criterion of polynomials and field of quotients help in understanding the field extensions and Galois theory which is part of the second semester syllabus. CO5:Overall at the end of the semester, students can solve a wide range of mathematical problems involving the structures of groups, normal subgroups, factor groups, rings, ideals and factor rings.
Teaching Learning Strategies	Direct Instruction: Brainstorming lecture, Problem solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active co-operative learning, Seminars, Assignments, Library work and Group discussion, Presentation by individual student/ Group representative.
Mode of Transaction	Face to face: Lecture method Learner centered technique: Computer assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Tutorial with Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Code & Title	**MSMAT01DSC02 - LINEAR ALGEBRA**	
Course Objectives	The Course aims Equip students with a profound comprehension of linear algebra, which will serve as a solid foundation for further studies, particularly in the context of functional analysis course	
	Content	**Module Outcome**
Module I: (15 hours)	Vector spaces (Quick review) Linear Transformations The Algebra of Linear Transformations Isomorphism (Chapter 2, Chapter-3; Sections 3.1, 3.2,3.3 of text 1)	Students are able to:Demonstrate a thorough understanding of vector spaces, including their properties and examples. Apply concepts of linear transformations and matrix representations to solve mathematical problems. Analyze and perform algebraic operations on linear transformations. Identify and establish isomorphisms between vector spaces.

Module II: (15 hours)	Representation of Transformation by Matrices Linear Functionals The Double Dual The Transpose of a Linear Transformation. (Chapter 3, sections 3.4, 3.5, 3.6, 3.7 of text 1)	Represent linear transformations using matrices and understand their applications. Apply linear functionals to analyze and solve problems related to vector spaces. Grasp the concept of the double dual and its significance in linear algebra. Understand and apply the concept of transpose in the context of linear transformations
Module III: (15 hours)	Elementary Canonical Forms: Introductions, Characteristic Values Annihilating Polynomials Invariant Subspace (Chapter-6: Sections 6.1, 6.2, 6.3, 6.4 of text 1)	Comprehend and apply elementary canonical forms to analyze linear transformations. Calculate and interpret characteristic values of linear transformations. Utilize annihilating polynomials for solving problems in linear algebra. Identify and analyze invariant subspaces within linear transformations
Module IV: (15 hours)	Jordan Canonical form and applications (Chapter 5, 5.1 to 5.3 of Text 2) Inner Product Spaces: Inner Products, Inner Product Spaces, (Chapter-8: Sections 8.1, 8.2 of text 1)	Understand the concept of Jordan canonical form and its applications in linear algebra. Apply Jordan canonical form to analyze and solve problems related to linear transformations. Demonstrate a solid understanding of inner product spaces and their properties. Give a base to study functional Analysis

References	<u>**Text Books**</u>: Text 1. Kenneth Hoffman & Ray Kunze; Linear Algebra; Second Edition, Prentice-Hall of India Pvt. Ltd Text 2: D W Lewis, Matrix Theory, World Scientific – (section 1, module 4) <u>**References**</u>: 1. Serge A Lang: Linear Algebra; Springer 2. Paul R Halmos Finite-Dimensional Vector Spaces; Springer 1974. 3. Thomas W. Hungerford: Algebra; Springer 1980 4.S H Fried Berg ,A J Insel and L E Spence : Linear algebra , Pearson, fifth edition 5. N H McCoy& T R Berger: Algebra-Groups, Rings & Other Topics: Allyn & Bacon. 6. S. Axler Linear Algebra Done right , Springer
Course Outcomes	**After successful completion of this course, student will be able to:**
	CO1: Exhibit a strong grasp of core linear algebra concepts, including vector spaces, matrices, determinants, eigen values, eigen vectors, linear transformations and inner product spaces. CO2: Develop a rigorous mathematical mindset, understanding and using mathematical proofs and theorems related to linear algebra. CO3: Apply linear algebra techniques to solve a wide range of mathematical problems, such as systems of linear equations and matrix theory. CO4: Analyze and manipulate eigen values and eigen vectors to solve problems related to diagonalization. CO5: Equip students with a profound comprehension of linear algebra, which will serve as a solid foundation for further studies, particularly in the context of functional analysis course.

Teaching Learning Strategies	Direct Instruction: Brainstorming lecture, Problem solving sessions, Explicit Teaching, E-learning (Video), Interactive Instruction: Active co-operative learning, Seminars, Assignments, Library work and Group discussion, Presentation by individual student/ Group representative
Mode of Transaction	Face to face: Lecture method Learner centered technique: Computer assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Tutorial with Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Code & Title	**MSMAT01DSC03 ORDINARY DIFFERENTIAL EQUATIONS**
Course Objectives	The Course aims The objective of this course is to understand and analyze the solutions of some important types of ODEs. This serves as an important path from mathematics to physics and engineering.

Modules	**Content**	**Module Outcome**
Module I: 15 hours	The existence and uniqueness of solutions (The method of successive approximations, Picard's theorem, Systems - the second order linear equation) Qualitative properties of solutions (Oscillations and Sturm separation theorem, The Sturm comparison theorem) (Chapter 13: Sections - 69-71, Chapter 4: Sections - 24 and 25)	Students are able To: Get a proper understanding about existence and uniqueness of solutions of first order ODE

Module II: 15 hours	Power series solutions. (Introduction. A review of power series (an overview), series solutions of first order equations, second order linear equations – ordinary points, regular singular points, Gauss's hyper geometric equation, point at infinity) (Chapter 5, Section 26-29, 31 and 32)	Able to understand the existence of power series solutions and get used to the problem solving
Module III: 15 hours	Special Functions and System of First Order Equations (Special functions of mathematical physics: Legendre polynomial, Bessel functions, Gamma functions) Systems of first order equations. (General remarks on systems, linear systems, homogeneous linear systems with constant coefficients (Chapter 8, Sections 44-47,Chapter 10 sections 54-56)	Able to learn about some very important special functions of mathematical physics
Module IV: 15 hours)	Nonlinear equations (Autonomous systems. The phase plane and its phenomena, types of critical points, stability, critical points and stability for linear systems, stability by Liapunov's direct method, simple critical points of nonlinear systems) (Chapter 11, Sections 58-62)	Able to get an understanding about non linear ODE and its solutions.
References	**Textbook:** Differential equations with applications and historical notes by George F. Simmons (CRC Press, Third Edition, 2017) **References**: 1. Ordinary differential equations: Principles and applications by Ian A. K. Nandakumaran, P. S. Datti and Raju K. George Cambridge University Press, 1983) 2. An introduction to ordinary differential equations by Earl A. Coddington (Dover Books, 1989) 3. Ordinary differential equations by Birkhoff G. and G. C. Rota (Wiley, 1989)	
Course Outcomes	**After successful completion of this course, student will be able to:**	
	This is a basic first course on partial differential equations.. The expected outcomes of this course are:: CO1**:**Learn the existence and uniqueness of solutions of first order ODEs CO2: Learn the qualitative properties of solutions CO3: Learn about power series solutions, system of first order equations and some important special functions CO4: Learn about nonlinear equations	

Teaching Learning Strategies	Direct Instruction: Brainstorming lecture, Problem solving sessions, Explicit Teaching, E-learning (Video), Interactive Instruction: Active co-operative learning, Seminars, Assignments, Library work and Group discussion, Presentation by individual student/ Group representative
Mode of Transaction	Face to face: Lecture method Learner centered technique: Computer assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	**Marks**
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Tutorial with Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Code & Title	**MSMAT01DSC04 - REAL ANALYSIS**	
Course Objectives	The Course aims: Gaining a comprehensive understanding of advanced real analysis , which is the primary means of comprehending higher mathematics is the primary goal of this course	
Modules	**Content**	**Module Outcome**
Module I: **(20Hrs)**	Basic Topology-Finite, Countable and uncountable Sets Metric spaces, Compact Sets, Perfect Sets, Connected Sets. Continuity-Limits of function Continuous functions, Continuity and compactness, continuity and connectedness, Discontinuities, Monotonic functions, Infinite limits and Limits at infinity.	Students are able to: Determine if a particular function on a metric space is continuous or not, as well as distinguish between countable and uncountable sets.

Module II: **(10 Hours)**	Differentiation Derivative of a real function. Mean value theorems, Continuity of derivatives. L - Hospital's rule. Derivatives of higher order. Taylor's theorem. Differentiation of vector valued functions	Possess the ability to recognize differentiable functions as well as the continuity of derivatives. Alsoable to understand the various applications of the mean value theorem with clarity as well
Module III: (15 Hours)	Riemann – Stieltjes integral. Definition and existence of the integral. Integration and differentiation. Integration of vector – valued functions. Rectifiable curves.	Will gain understanding of Reiman Stieltjes integrals and be able to calculate a function's integral if it is integrable.Alsowill receive an overview of the relationship between differentiation and integration.
Module IV: (15 hours)	Sequences and series of functions Uniform convergence. Uniform convergence and continuity. Uniform convergence and differentiation. Equicontinuous families of functions. Stone – Weierstrass theorem.	Will gain understanding of the notion of the series of functions' point-wise and uniform convergence..Moreover capable of comprehending the idea of an equicontinuous family of functions
References	**<u>Textbook</u>:** Walter Rudin – Principles of Mathematical Analysis (3rd edition) – McGraw Hill, Chapters2,4, 5,6, and 7(up to and including 7.27 only) **<u>Reference Books</u>:** 1. T.M. Apostol – Mathematical Analysis (2nd edition) –Narosa 2. B.G. Bartle – The Elements of Real Analysis – Wiley International 3. G.F. Simmons – Introduction to Topology and Modern Analysis – McGraw Hill 4. Pugh, Charles Chapman:Real Mathematical Analysis, springer, 2015. 5. Sudhir R. Ghorpade , Balmohan V. Limaye, A Course in Calculus and Real Analysis (Undergraduate Texts in Mathematics) , springer, 2006	

Course Outcomes	**After successful completion of this course, student will be able to**: CO1: Students can distinguish between a countable set and an uncountable set. They can provide examples of compact sets and their opposites as well as provide clarification on the design and characteristics of Cantor sets. CO2: Students will be able to determine whether a function is continuous at a certain location. If there is a continuous map between them, students will also be able to analyze the concepts of compactness and connectedness of metric spaces. Additionally, the students will be able to determine whether a given function at a given position is differentiable. CO3 :Students will comprehend RiemannStieltjes integration of many types of functions better.: CO4: With the help of examples, students will gain understanding of the idea of uniform convergence of functions. They will comprehend how uniform convergence, continuity, and integration are related.

Teaching Learning Strategies	Direct Instruction: Brainstorming lecture, Problem solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active co-operative learning, Seminars, Assignments, Library work and Group discussion, Presentation by individual student/ Group representative
Mode of Transaction	Face to face: Lecture method Learner centered technique: Computer assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Tutorial with Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Code & Title	MSMAT01DSC05 - TOPOLOGY
Course Objectives	The Course aims Introduction to topological spaces. Emphasize the role of basis and subbasis in a topological spaces. Discuss the properties like connectedness, compactness and separation axioms in topological spaces. Identify homeomorphic objects.

Modules	Content	Module Outcome
Module I: (20 hours)	Topological spaces Basis for a topology The order topology The product topology(finite) The subspace topology Closed sets and limit points, (sections 12 to 17)	Students are able to: Recognize closed and open sets within a specific topological space. Comprehend the idea of topological spaces and the basis of a topology;
Module II: (15 hours)	Continuous functions The product topology The metric topology The metric topology (continued) The quotient topology (Sections 18-22)	Able to determine if a particular function is continuous or not between two topological spaces. Also capable of understanding the notions of product and metric topologies
Module III: (10 hours)	Connected spaces, Connected subspace of the real line, Compact spaces, compact subset of the real line (sections 23,24, 26, 27)	Capable of recognizing compact and connected topological spaces
Module IV: (15 hours)	The countability axioms The separation axioms Normal spaces The Urysohn lemma The Urysohn Metrization Theorem (without proof) Tietze extension Theorem (without proof) The Tychonoff theorem (without proof) (sections 30, 31, 32, 33,34, 35, 37)	Able to provide examples of topological spaces meeting various separation axioms. Capable of stating and proving the Urysohn lemma as well as elucidating the significance of the Tychonoff and Tietze extension theorems

References	**<u>Textbook</u>:** J.R. Munkres – Topology, Second edition Pearson India, 2015. **<u>Reference Books</u>:** 1. K Parthasarathy, Topology an invitation, Springer (2022) 2. K.D. Joshi – Introduction to General Topology, New age International (1983) 3. G.F. Simmons–Introduction to Topology & Modern Analysis–McGrawHill 4. M.Singer and J.A. Thorpe – Lecture Notes on Elementary Topology and Geometry, Springer Verlag 1967 5. Kelley J.L. – General Topology, von Nostrand 6. Stephen Willard – General Topology, Dover Books in Mathematics.
Course Outcomes -------------------	After successful completion of this course, student will be able to: --- CO1: The student will have a solid understanding of fundamental concepts in point set topology such as open sets , closed sets, neighborhoods and topological spaces. CO2 : The student will be proficient in defining and working with basis and subbases for topological spaces. CO3: The student will be able to construct and analyze product topology and subspace topology. CO4: The Student will understand connectedness and compactness and will be able to identify homeomorphic spaces. CO5: The student will get the ability to solve a variety of problems demonstrating the application of topological spaces.

Teaching Learning Strategies	Direct Instruction: Brainstorming lecture, Problem solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active co-operative learning, Seminars, Assignments, Library work and Group discussion, Presentation by individual student/ Group representative
Mode of Transaction	Face to face: Lecture method Learner centered technique: Computer assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Tutorial with Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

SECOND SEMESTER M.Sc. MATHEMATICS PROGRAMME

SCHEME

SECOND SEMESTER								
Course Code	**Title of Course**	**Contact Hours/Week**			**Marks**			
		L	**T/S**	**P**	**ESE**	**CE**	**Total**	**Credits**
DISCIPLINE-SPECIFIC CORE COURSES								
MSMAT02DSC06	**Algebra II**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT02DSC07	**Complex Analysis**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT02DSC08	**Functional Analysis I**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT02DSC09	**Functions of Several Variables and Differential Geometry**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT02DSC10	**Measure and Integration**	**4**	**1**		**60**	**40**	**100**	**4**
ABILITY ENHANCEMENT COURSE								
MSMAT02AEC1	**Set Theory and Logic (For other departments)**	**2**	**1**		**30**	**20**	**50**	**2**
----------	**Taken from other Departments**	**2**	**1**		**30**	**20**	**50**	**2**
SKIL ENHANCEMENT COURSE								
MSMAT02SEC1	**A Basic Course in Latex (For other departments)**	**2**	**1**	**1**	**30**	**20**	**50**	**2**
----------	**Taken from other Departments**	**2**	**1**		**30**	**20**	**50**	**2**
	Total	**24**	**6**	**1**	**360**	**240**	**600**	**24**

Note: -L:Lecture ,T/S :Tutorial/Seminar, P :Practical ,ESE : End Semester Evaluation, CE Continuous Evaluation

DISCIPLINE-SPECIFIC CORE COURSES

Course Code & Title	**MSMAT02DSC06- ALGEBRA II**
Course Objectives	The Course aims The aim of this course is to learn the Galois Theory.

Module	**Content**	**Module Outcome**
I (15 Hours)	Introduction to extension fields. Algebraic extensions. Geometric constructions. (Chapter 6 Sections 29, 31, 32.)	Able to prove that every non-constant polynomial has a zero in an extended field. Also able to prove that there exists an angle that cannot be trisected using a straight edge and a compass
II (15 Hours)	Unique factorization domains, Euclidean domains; Gaussian integers and multiplicative norms. (Chapter 9 Section 45,46,47 of the Text Book .)	Will get an idea about UFD and PID. Also able to find an example of a Euclidean domain different from Z and F[x]
III (15 Hours)	Finite fields. Automorphisms of fields, The isomorphism extension theorem,. splitting fields (Chapter 6 Section33, Chapter 10 Sections 48,49,50 of Text 1.)	Will be familiar with the concept of automorphism of fields and the concept of splitting field

IV (15 Hours)	Splitting fields, separable extensions, Totally inseparable extensions, Galois theory, Illustrations of Galois theory (Chapter 10 Section 51,52,53,54)	Will get an idea about the multiplicity of zeros of polynomials. Will get a clear idea about the main concepts of Galois theory

References	**TEXT BOOK:** Fraleigh – A First Course in Abstract Algebra- Narosa (7th edn.), 2003 **REFERENCES:** 1. J.A.Gallian – Contemporary Abstract Algebra 2. Hoffman & Kunze – Linear Algebra – Prentice Hall 3. P.B. Bhattacharya, S.K. Jain, S.R. Nagpal – Basic Abstract Algebra 4. M. Artin – Algebra, Prentice Hall, 199	

Course Outcome	After successful completion of this course, students will be able to:
	1. Able to prove that every non-constant polynomial has a zero in an extended field 2. Also able to find an example of a Euclidean domain different from Z and F[x] 3. Familiar with the concept of automorphism of fields and the concept of splitting field 4. Get an idea about the multiplicity of zeros of polynomials. 5. Get a clear idea about the main concepts of Galois theory
Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Course Code & Title	MSMAT02DSC07- COMPLEX ANALYSIS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Objectives	The Course aims Complex analysis is one of the classical branches of Mathematics. Complex analysis is an extremely powerful tool with an unexpectedly large number of practical applications to the solution of physical problems. Complex analysis, in particular the theory of conformal mappings, has many physical applications and is also used throughout analytic number theory. In modern times, it has become very popular through a new boost from complex dynamics and the pictures of fractals produced by iterating holomorphic functions. This course aims to lay a strong foundation for the theory of complex analysis

Module	Content	Module Outcome
I (15 Hours)	The extended plane and its spherical representation Power series, Analytic functions, Analytic functions as mappings, Mobius transformations. (Chapt. I Section 6;, Chapt. III Sections 1,2 and 3)	1. Students will be able to interpret and work with the extended plane, gaining proficiency in understanding its topological properties and how it is represented on the sphere. They will be able to visualize complex numbers in the context of the Riemann sphere, enhancing their geometric intuition. 2.Students will develop a comprehensive understanding of power series, analytic functions, Cauchy Riemann equations and their role in ensuring the differentiability of complex functions . They will be able to manipulate power series, determine their convergence regions, and apply them to represent complex functions. The emphasis will be on both theoretical aspects and practical applications. 3. Students will explore how analytic functions serve as mappings between complex planes. They will be able to analyze the behavior of these mappings, including the preservation of angles and conformal properties. This knowledge will be applied to visualize and understand complex transformations in different domains.

II (15 Hours)	Reimann-Stieltijes integrals Power series representation of analytic functions, Zeros of an analytic functions The index of a closed curve [Chapter IV: Sections 1,2,3,4]	**1**.Students will develop a deep understanding of Riemann-Stieltjes integrals, including the theory behind the integration of functions. They will be able to apply these integrals to analyze and solve complex problems in mathematical modeling and analysis. 2. Upon completion of this module, students will master the techniques of representing analytic functions as power series. They will be able to manipulate power series to express complex functions and determine convergence regions. Students will apply these skills to represent a wide range of analytic functions in power series form. 3. Students will investigate the properties of zeros of analytic functions, understanding the relationship between the zeros and the behavior of the function. Also develop a solid understanding of the index of a closed curve in the complex plane. They will be able to calculate the index using various methods, such as the winding number and contour integration. The application of the index to analyze the behavior of complex functions around curves will be a key focus.

III (15 Hours)	Cauchy’s Theorem and Integral Formula The homotopic version of Cauchy’s Theorem and simple connectivity (Omit proof of third version of Cauchy’s theorem), Counting zeros; the open mapping Theorem and Goursat’s Theorem. [Chapter IV: Sections 5, 6(Omit proof of third version of Cauchy’s theorem) 7 and 8]	1.Students will acquire a deep understanding of Cauchy's Theorem and the corresponding integral formula, emphasizing the relationship between the analyticity of functions and the behavior of their line integrals. They will be able to apply these theorems to evaluate complex integrals and analyze the properties of analytic functions. 2.Upon completion of this module, students will master the homotopic version of Cauchy’s Theorem and the concept of simple connectivity. They will understand how these concepts extend the applicability of Cauchy's Theorem to other regions 3.Students will explore advanced techniques for counting zeros of analytic functions, emphasizing the use of the argument principle. They will also develop a profound understanding of the open mapping theorem and Goursat’s Theorem

IV (15 Hours)	The classification of singularities, residues The Argument principle and Maximum Principle. Schwarz's Lemma [Chapter V: sections 1,2 and 3; Chapter VI: sections 1 and 2]	1. Students will develop a comprehensive understanding of singularities in complex functions and their classification into removable, poles, and essential singularities. They will also master the calculation of residues, emphasizing their importance in contour integration and the evaluation of complex integrals. 2.Students will explore the Maximum Principle and its applications in complex analysis. They will understand how the principle establishes bounds on the modulus of analytic functions and its consequences for the behavior of functions within their domains. 3.Students will master Schwarz's Lemma and its implications for holomorphic functions. They will understand how this lemma provides information about the mapping properties of holomorphic functions on the unit disk.

References	**<u>TEXTBOOK</u>:** John B. Conway, Functions of One Complex Variables (2nd Edn); Springer International Student Edition; **.** **<u>REFERENCES:</u>** 1. L.V.Ahlfors – Complex Analysis (3rd edition); Mc Graw Hill International; 1979 2. H. Cartan: Elementary Theory of analytic function functions of one or several variables; Addison- WesleyPub.co.; 1973 3. T.W. Gamelin: Complex Analysis; Springer-Verlag, NY.; 2001 4. T.O.Moore and E. H. Hadlock: Complex Analysis, Series in Pure mathematics- Vol. 9; WorldScientific; 1991 5. L.Pennisi: Elements of Complex Variables(2nd Edn.); Holf, Rinehart &Wintson;1976 6. R. Remmert: Theory of Complex Functions; UTM, Springer-Verlag, NY; 1991 7. W. Rudin: Real and Complex Analysis (3rd Edn.); Mc Graw- Hill International Editions; 1987 8. H. Silverman: Complex Variables; Houghton Mifflin Co. Boston; 1975 9. R. Nevanlinna &Veiko Paatero: Introduction to Complex Analysis, Second edition (Indian Edition 2013) American Mathematical Society. 10. S Lang: Complex Analysis, Fourth Edition, (Indian edition 2013), Springer Verlag. 11. S. Ponnuswamy & Herb Silverman: Complex Variables with applications, Birkhauser. 12. K. KodairA, Complex Analysis, Cambridge University Press, 2008

Course Outcome	**After successful completion of this course, students will be able to:**
	CO1: Students will demonstrate advanced proficiency in a wide range of complex analysis techniques, including power series representation, the classification of singularities, and the application of Cauchy’s Theorem. They will be able to analyze and manipulate complex functions, applying these techniques to solve complex mathematical problems. CO2: Upon completion of the course, students will have mastered key theorems such as Cauchy’s Theorem, the open mapping theorem, and principles like the Argument Principle and Maximum Principle. They will be able to apply these theorems and principles to analyze the behavior of complex functions, count zeros and poles, and establish qualitative properties of analytic functions. CO3: Students will demonstrate proficiency in applying advanced concepts such as the homotopic version of Cauchy’s Theorem, Schwarz’s Lemma, and Goursat’s Theorem. They will be able to analyze regions in the complex plane, determine simple connectivity, and establish properties of holomorphic functions using these concepts. CO4:Through the study of the classification of singularities and the calculation of residues, students will develop skillful techniques for analyzing complex functions. They will be able to classify singularities, calculate residues, and apply these concepts to evaluate complex integrals and contour integrals. CO5: Students will be able to learn other subjects like functional analysis using the complex analysis.

Teaching Learning Strategies	Direct Instruction: Brainstorming lecture, Problem solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active co-operative learning, Seminars, Assignments, Library work and Group discussion, Presentation by individual student/ Group representative.
Mode of Transaction	Face to face: Lecture method Learner centered technique: Computer assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Code & Title	**MSMAT02DSC08 - FUNCTIONAL ANALYSIS I**
Course Objectives	The Course aims The aim of the course is to the study some of the features of bounded operators in Banach spaces and Hilbert spaces. Discusses the fundamental results like Hahn- Banach Theorem, Closed graph Theorem, Open mapping Theorem and their consequences

Module	Content	Module Outcome
I (15 Hours)	Vector space, Normed space, Banach space, Further Properties of Normed spaces, Finite dimensional normed spaces and subspaces, compactness and finite dimension, linear operators, Bounded and continuous linear operators, linear functionals(Section 2.1 to 2.8)	**1**. Students will be able to analyse properties vector spaces, normed spaces, and Banach spaces, including the properties and characteristics that define these mathematical structures. 2. Upon completion of this module, students will exhibit a mastery of further properties associated with normed spaces, showcasing their ability to manipulate norms, understand convergence in normed spaces, and apply these concepts to problem-solving 3. Students will develop the ability to work with linear operators, bounded and continuous linear operators, and linear functionals. They will be able to analyze the properties of these operators and apply them to solve problems in various mathematical contexts.

II (15 Hours)	Linear operators and functionals on finite-dimensional spaces, normed spaces of operators. Dual space, (up to 2.10.6) , Inner Product spaces. Hilbert spaces, Further properties of inner product spaces, Orthogonal complements and direct sums, Orthonormal sets and sequences, series related to orthonormal sequences and sets (Definitions and statement of results), total orthonormal sets and sequences (up to 3.6.4), Legendre, Hermite and Laguerre Polynomials (Definitions),(Section 2.9 to 3.7	1. Students will get the ability to analyze and manipulate linear operators algebraically and apply them to solve problems in functional analysis 2. Upon completion of this module, students will exhibit proficiency in the properties of inner product spaces, including the exploration of orthogonal complements, direct sums, and further advanced properties. 3. Students will be able to apply the concept of normed spaces of operators, demonstrating their ability to analyze and work with operators in a normed space setting.
III (15 Hours)	Representation of Functionals on Hilbert spaces, Hilbert-Adjoint operator, Self adjoint, unitary and normal operators, Zorn's lemma, Hahn-Banach theorem, Hahn-Banach theorem for complex vector spaces and normed spaces, Application to bounded linear functional on C[a,b] (Definitions only), (section 3.8 to 4.4)	1. Students will demonstrate proficiency in the representation of functionals on Hilbert spaces, showcasing their ability to work with Hilbert-Adjoint operators, and analyse the properties of self-adjoint, unitary, and normal operators. They will be able to apply these concepts to represent various classes of operators and functionals, highlighting their importance in functional analysis. 2. Upon completion of this module, students will have mastered fundamental theorems such as Zorn's lemma and the Hahn-Banach theorem. They will be able to apply these theorems to prove results in complex vector spaces and normed spaces, demonstrating their proficiency in using these powerful tools in functional analysis.

IV (15 Hours)	Adjoint operator (4.5, up to 4.5.2), Reflexive spaces (4.6, Definitions), Category Theorem, Uniform Boundedness Theorem(4.7.1-4.7.3), Strong and weak convergence (4.8, up to 4.8.3), Open mapping theorem (4.12), closed linear operators, closed graph theorem (4.13).(sections 4.5 (up to 4.5.2) to 4.8.3, 4.12 to 4.13)	1. Students will get proficiency in understanding and working with adjoint operators, reflexive spaces, and various convergence concepts, including strong and weak convergence. 2. Upon completion of this module, students will be able to apply fundamental theorems such as the category theorem, uniform boundedness theorem, and open mapping theorem to analyze the properties of linear operators.

References	**TEXT BOOK** : E. Kreyszig, Introductory Functional Analysis with Applications (Wiley) **REFERENCES**: 1. B.V. Limaye – Functional Analysis (3rd edition) – New Age International, 2014. 2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963. 3.M.Thamban Nair, Functional Analysis: A First Course, PHI, 2014. 4.R. Bhatia. : Notes on Functional Analysis TRIM series, Hindustan Book Agency, 5. Kesavan S, : Functional Analysis TRIM series, Hindustan Book Agency, 2009 6 . George Bachman & Lawrence Narici : Functional Analysis , Dover books on mathematics (1966, 2000) 7. Yuli Eidelman, Vitali Milman, and Antonis Tsolomitis, : Functional analysis An Introduction. Graduate Studies in Mathematics Vol. 66 American Mathematical Society 2004.

Course Outcome	After successful completion of this course, student will be able to:
	CO1 : Students will demonstrate advanced proficiency in the fundamental concepts of functional analysis, including vector spaces, normed spaces, Hilbert spaces, and operator theory. They will be able to analyse and apply these concepts to solve complex problems in the related area. CO2: Upon completion of the course, students will have mastered operator theory, including the representation of functionals, adjoint operators, and the properties of self-adjoint, unitary, and normal operators. They will apply these concepts to analyse and represent linear operators, highlighting their significance in functional analysis CO3: Students will demonstrate the ability to apply fundamental theorems such as Zorn's lemma, the Hahn-Banach theorem, the category theorem, and the uniform boundedness theorem. They will apply these theorems to prove results in complex vector spaces, normed spaces, and analyse the properties of linear operators. CO4: Through the study of strong and weak convergence, students will gain a comprehensive understanding of convergence concepts in functional analysis. They will be able to analyse the convergence of sequences and applying these concepts to establish convergence properties. CO5: Students will be able to apply the concepts and theorems learned in the course to solve problems in functional analysis principles to address complex challenges in diverse applications.

Teaching Learning Strategies	Direct Instruction: Brainstorming lecture, Problem solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active co-operative learning, Seminars, Assignments, Library work and Group discussion, Presentation by individual student/ Group representative.

Mode of Transaction	Face to face: Lecture method Learner centered technique: Computer assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Code & Title	**MSMAT02DSC09 FUNCTIONS OF SEVERAL VARIABLES AND DIFFERENTIAL GEOMETRY**
Course Objectives	The Course aims: The course gives an introduction to the elementary concepts of differential geometry using the calculus of vector fields so that the students also attain a deep understanding of several variable calculus.

Module	Content	Module Outcome
I (15 Hours)	Functions of Several variables: 1. Linear transformations 2. Differentiation 3. The contraction principle 4. The inverse function theorem 5. The implicit function theorem (Text 1, Chapter 9, Sections 1-29)	The main aim of this module is to get a proper understanding of the functions of several variables and the differentiation of such functions.
II (15 Hours)	Surfaces and vector fields: 1. Graphs and level sets 2. Vector fields 3. Tangent spaces 4. Surfaces 5.Vector fields on surfaces, orientation 6. Gauss map (Text 2, Chapters 1-6)	This module is intended to make students comfortable in the preliminaries of differential geometry. The students are expected to understand graphs, level sets, tangent spaces and surfaces.
III (15 Hours)	Weingarten map and curvature: 1. Geodesics 2. Parallel transport 3. The Weingarten map 4. Curvature of plane curves (Text 2, Chapters 7-10)	This module is intended to understand important concepts such as Weingarten map and curvature. As a first step to understand the curvature of surfaces, it is important to learn about the curvature of plane curves.
IV (15 Hours)	Curvature of surfaces: 1. Arc length and line integrals 2. Curvature of surfaces (Text 2, Chapters 11-12)	This module deals with line integrals and curvature of surfaces. These are the most important objectives of this differential geometry course.

References	**<u>TEXT 1</u>:** Principles of Mathematical Analysis by W. Rudin (Mc.Graw Hill, 1986) **<u>TEXT 2:</u>** Elementary Topics in Differential Geometry by J. A. Thorpe (Springer-Verlag, 2011) **<u>REFERENCES:</u>** 1. Elementary Differential Geometry by Andrew Pressley (Springer-Verlag, 2010) 2. Differential geometry of Curves and Surfaces by M. P. do Carmo (Dover Publications, 2016) 3. Mathematical Analysis by T. M. Apostol (Pearson, 1974) 4. Analysis on Manifolds by james R. Munkres (Addison-Wesley Publishing Company, 1991)

Course Outcome	After successful completion of this course, students will be able to:
	1. Be proficient in the differentiation of functions of several variables. 2. Understand the curves in plane and in space 3. Get a deep knowledge of curvature, torsion and Serret-Frenet formulae 4. Learn the fundamental theorem of curves in plane and space 5. Learn the concept of surfaces in three dimension, smooth surfaces and surfaces of revolution 6. Learn tangent and normal to the surfaces understand oriented surfaces, first and second fundamental forms surfaces, Gaussian curvature and geodesic curvature

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning (Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion, and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

Course Code & Title	**MSMAT02DSC10- MEASURE AND INTEGRATION**
Course Objectives	The Course aims The main aim is to get a clear picture of the abstract measure theory and Lebesgue integral, which are essential for the study of advanced analysis.

Module	Content	Module Outcome
I (15 Hours)	Introduction. Measurable functions. Measures	Students are able to: understand the reason for the development of Lebesgue integral in comparison with the Reimann integral. Also will get an idea of measure and measure space
II (15 Hours)	The integral. Integrable functions. Lp – spaces	Will get an idea on how the Lebesgue integral of measurable functions can be computed. Will get an idea of the concept of L_p spaces
III (15 Hours)	Modes of convergence	Will get the concept of convergence in measure and almost uniform convergence. Two important theorems viz Egoroff's theorem and Vitali convergence theorem are stated and proved
IV (15 Hours)	Generation of measures. Decomposition of measures.	Will learn the different ways of decomposing measures and charges. Also learn how to construct Lebesgue measure on the real line from the length of an interval
References	<u>**TEXT BOOK**</u> **:** R.G. Bartle – The Elements of Integration (1966), John Wiley & Sons <u>**REFERENCES:**</u> 1. H.L. Royden – Real Analysis –Macmillan 2. de Barra – Measure and Integration 3. Inder K. Rana – Measure and Integration – Narosa	

Course Outcome	After successful completion of this course, students will be able to:
	1. Understand the reason for the development of the Lebesgue integral in comparison with the Reimann integral. 2. Get an idea of measure and measure space 3.Get an idea on how the Lebesgue integral of measurable

	functions can be computed. 4.Get an idea of the concept of L_p spaces 5.Get the concept of convergence in measure and almost uniform convergence 6.Learn the different ways of decomposing measures and charges. Also learn how to construct Lebesgue measure on the real line from the length of an interval

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion, and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

ABILITY ENHANCEMENT COURSE

Course Code & Title	**MSMAT02AEC1- SET THEORY AND LOGIC**
Course Objectives	The Course aims Introduce the concept of set ,which formalizes the idea of grouping objects together and viewing them as a single entity . Also introduce some basic concepts of logic associated with elementary theory of sets

Module	**Content**	**Module Outcome**
I (15 Hours)	Sets and basic operations on sets Arguments and Venn diagrams Mathematical induction [Complete content of the chapter 1 of the text book]	Students are able to: Get the concept of set ,which formalizes the idea of grouping objects together and viewing them as a single entity. Able to do basic operations of sets .Also able to determine validity of certain arguments using Venn diagrams
II (15 Hours)	Basic logical Operations Logical equivalence Negation of quantified statements [Complete content of the chapter 10 of the text book]	Able to compute truth values of logical expressions and quantified statements

References	**TEXT BOOK :** Schaum's outline of Set theory and related topics (Second edition) Seymour Lipschutz

Course Outcome	**After successful completion of this course, students will be able to:**
	1.Get the concept of set ,which formalizes the idea of grouping objects together and viewing them as a single entity. 2.Able to do basic operations of sets . 3.Also able to determine validity of certain arguments using Venn diagrams 4.Able to compute truth values of logical expressions and quantified statements
Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion, and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASESSMENT RUBRICS

Components	**Marks**
End Semester Evaluation	30
Continuous Evaluation	20
Test papers	8
Seminar presentations/Discussions/Debate, etc.	8
Assignment	4

SKILL ENHANCEMENT COURSE

Course Code & Title	**MSMAT02SEC1- A BASIC COURSE IN LATEX**
Course Objectives	The Course aims • To understand the importance of Latex in scientific typing and importance of using online methods for typing. • To understand the basic Latex typing techniques and get a practical knowledge of how to type a Project Report/ Research Paper

Module	Content	Module Outcome
I (15 Hours)	Understanding the Importance of Latex and the Basics 1.1 What is Latex?. The main features 1.2 Online overleaf access 1.3 Title, sections, command and arguments 1.4 Labelling table of contents, font effects, coloured texts and font sizing 1.5 Comments, spacing, special characters [Chapters 1 and 2 of the text book]	The main aim of this module is to get a proper understanding about the basic latex language and understand the title, table of contents, colour texts and font settings.
II (15 Hours)	Equations, Symbols and Project/Thesis Report Typing 2.1 Lists, tables and figures 2.2 Equations and symbols 2.3 Reference: Bibliography styles 2.4 report typing: thesis/ project report 2.5 Document classes: article, book. beamer and slides [Chapters 3 and 4 of the text book]	This module is intended to make students comfortable in the typing of project reports. To attain this they are expected to learn the references and document classes in Latex.

References	**<u>TEXT BOOK</u> :** Guide to LATEX, fourth edition, Helmut Kopka, Patrick W.Daly **https://www.math.ucdavis.edu/~tracy/courses/math129/Guide_To_LaTeX.pdf** **<u>REFERENCES</u>** **1.Overleaf learning material https://www.overleaf.com/learn** **2.https://mirror.niser.ac.in/ctan/macros/latex/contrib/beamer/doc/beameruserguide.pdf**

Course Outcome	**After successful completion of this course, students will be able to:**
	Understand the importance of Latex language. Understand the basic settings and syntax of Latex . Learn the typing of different types of equations and also typing the references Get a practical knowledge of how to type a Project Report/Research Paper
Teaching Learning Strategies	Direct Instruction: Explicit teaching, Brainstorming lectures, Problem solving sessions, , E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion, and Presentation by individual student/ Group representatives.

Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASESSMENT RUBRICS

Entire (both internal and external) evaluation is done through practical examination

Components	Marks
End Semester Evaluation	30 (Full Practical)
Continuous Evaluation	20
Test papers	8 (Practical)
Seminar presentations/Discussions/Debate, etc.	8
Assignment	4 (Practical)

To overcome the difficulty of getting qualified external expert, the End semester evaluation of this course may be done by a board consisting of the Head of the Department of Mathematical Sciences of Kannur University as chairman and the teacher teaching the course as a member

THIRD SEMESTER M.Sc. MATHEMATICS PROGRAMME

SCHEME

THIRD SEMESTER								
Course Code	**Title of Course**	**Contact Hours/Week**			**Marks**			
		L	**T/S**	**P**	**ESE**	**CE**	**Total**	**Credits**
DISCIPLINE-SPECIFIC CORE COURSES								
MSMAT03DSC11	**Functional Analysis II**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT03DSC12	**Partial Differential Equations**	**4**	**1**		**60**	**40**	**100**	**4**
DISCIPLINE-SPECIFIC ELECTIVE COURSE (Choose one)								
MSMAT03DSE1	**Fuzzy Mathematics**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT03DSE2	**Operations Research**	4	1		60	40	100	4
MSMAT03DSE3	**Stochastic Processes**	4	1		60	40	100	4
MULTIDSCIPLINARY ELECTIVE COURSE								
MSMAT03MDC1	**Calculus with an Introduction to Linear Algebra (For other Departments)**	**4**	**1**		**60**	**40**	**100**	**4**
------------	**Taken from other Departments**	4	1		60	40	100	4
	Total	**16**	**4**		**240**	**160**	**400**	**16**

Note: -L:Lecture ,T/S :Tutorial/Seminar, P :Practical ,ESE : End Semester Evaluation, CE Continuous Evaluation

MSMAT03DSC11 FUNCTIONAL ANALYSIS II

Course code & Title	MSMAT03DSC11 FUNCTIONAL ANALYSIS II
Course objectives	The course aims: The objective of this course is to delve into the spectral theory concerning both compact linear operators and bounded self-adjoint linear operators.

Module	Content	Module Outcome
I (15 Hours)	Approximation in normed spaces, Uniqueness, strict convexity, Uniform approximation, Approximation in Hilbert space, Spectral Theory in finite dimensional normed spaces , Basic concepts, (section , 6.1 , 6.2, 6.3, 6.5 , 7.1 & 7.2)	1.Students will able to Understand approximation methods and techniques in normed spaces, which allows for the approximation of functions or elements by simpler or more manageable ones 2.Uniform approximation deals with approximating functions uniformly over a given domain. This is important in various areas such as signal processing, control theory, and numerical methods for solving differential equations
II (15 Hours)	Spectral properties of bounded linear operators, Further properties of resolvent and spectrum, Use of complex analysis in spectral theory, Banach algebras, Further properties of Banach algebras, compact linear operators on normed spaces, Further properties of compact linear operators (7.3 to 8.2)	1.Able to understand spectral properties, which is crucial for analyzing linear operators in various contexts, including differential equations and quantum mechanics 2.Will get a Knowledge in compact operators, which is essential for studying integral equations, Fredholm theory, and the spectral decomposition of operators.

III (15 Hours)	Spectral properties of compact linear operators on normed spaces, Further spectral properties of compact linear operators, Operator equations involving compact linear operators, spectral properties of bounded self adjoint linear operators, further spectral properties of bounded self adjoint linear operators (section 8.3 to 8.5 & 9.1 to 9.2)	1Will get knowledge of spectral properties, which helps in characterizing the eigenvalues, eigenvectors, and spectrum of compact operators, enabling their use in solving integral equations, Fredholm theory, and approximation problems 2.Will get spectral properties, which provide insights into the eigenvalues, eigenvectors, and spectrum of self-adjoint operators, enabling their use in solving boundary value problems, quantum mechanical systems, and spectral theory.
IV (15 Hours)	Positive operators, square root of a positive operator, projection operators, further properties of projections, spectral family, spectral family of a bounded self adjoint linear operators, spectral representation of bounded self adjoint linear operators. (sections 9.3 to 9.9)	1.Will get good Knowledge of positive operators allows for the analysis of positivity-preserving transformations and the study of properties such as monotonicity, convexity, and order structures. 2. By Studying the spectral family of bounded self-adjoint operators, involves understanding its properties, including completeness, resolution of the identity, and functional calculus

References	**TEXT BOOK** : E. Kreyszig, Introductory Functional Analysis with Applications (Wiley) **REFERENCES** 1 B.V. Limaye – Functional Analysis (3rd edition) – New Age International, 2014. 2. M.Thamban Nair, Functional Analysis: A First Course, PHI, 2014. 3. R. Bhatia. : Notes on Functional Analysis TRIM series, Hindustan Book Agency, 2009 4. Sunder V.S, : Functional Analysis spectral theory, TRIM Series, Hindustan Book Agency,1997 5 . George Bachman & Lawrence Narici : Functional Analysis , Dover books on mathematics (1966, 2000) 6 . Yuli Eidelman, Vitali Milman,and Antonis Tsolomitis, : Functional analysis An Introduction, Graduate Studies in Mathematics Vol. 66 American Mathematical Society 2004.

Course Outcome	**After successful completion of this course, students will be able to:**
	1.Studying this course equips learners with theoretical knowledge and practical skills applicable in various fields, ranging from pure mathematics to applied sciences and engineering 2. Studying this course provides a comprehensive understanding of advanced topics in functional analysis and operator theory, with applications in mathematics, physics, engineering, and other disciplines. 3.Studying this course provides a comprehensive understanding of advanced topics in spectral theory, operator theory, and functional analysis, with applications in various mathematical disciplines and scientific fields. 4. Studying this course provides a comprehensive understanding of advanced topics in spectral theory, operator theory, and functional analysis, with applications in various mathematical disciplines and scientific fields.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT03DSC12 PARTIAL DIFFERENTIAL EQUATIONS II

Course code & Title	**MSMAT03DSC12 PARTIAL DIFFERENTIAL EQUATIONS**
Course objectives	The objective of this course is to familiarize the students with fundamental concepts of partial differential equations

Module	Content	Module Outcome
I (15 Hours)	Unit I: First Order Partial Differential Equations: Method of Characteristics 1. First order PDE: 1.1 Introduction variables 1.2 First order 1.3 Quasi linear equations 1.4 General first order equation in two variables 1.5 First order equation in several variable Chapter 3: Sections - 3.1, 3.2, 3.3, 3.4 and 3.5	The aim of this module is to get familiar with the first order PDE
II (15 Hours)	Unit 2: Classification of second Order PDE 1. Classification of second order equations 1.1 Introduction 1.2 Cauchy problem 1.3 Classification of linear equations 1.4 Higher order linear equations Chapter 6: Sections - 6.1, 6.2, 6.3 and 6.4	This module is intended to learn the second order PDE and its classification

III (15 Hours)	Unit 3: Laplace and Heat Equation 1. Laplace and Poisson equation 1.1 Physical interpretation 1.2 Fundamental solutions 1.3 Mean value formula 1.4 Maximum principles Chapter 7: Sections - 7.1 and 7.2 2. Heat Equation 2.1 Derivation of one-dimensional heat equation 2.2 Heat transfer in an unbounded rod 2.3 Heat equation on finite interval : Fourier method Chapter : Sections - 8.1. 8.2 and 8.4	The aim of this module is to learn the well known PDE problems such as heat and Laplace equations.
IV (15 Hours)	Unit 4: One Dimensional Wave Equation 1. Classification of second order equations 1.1 Introduction 1.2 Cauchy problem on the line 1.3 Cauchy problem in a quadrant 1.4 Wave equation in a finite interval Chapter 9: Sections - 9.1, 9.2, 9.3 and 9.4	This module is focusing on the study of wave equations.

References	Textbook: Partial Differential Equations: Classical Theory with a Modern Touch by A. K. Nandakumaran and P. S. Datti (Cambridge University Press, 2020) References: 1. Partial differential Equations by Lawrence C. Evans (American Mathematical Society, 2010) 2. Elements of Partial Differential Equations by Ian Sneddon (McGraw Hill, 1983) 3. An elementary Course in partial differential Equations by T. Amarnath (Narosa Publishing House 2003)

Course Outcome	**After successful completion of this course, students will be able to:**
	This is a basic first course on partial differential equations.The expected outcomes of this course are: 1. Learn some techniques to solve first order PDE and and analyze the solution. 2. Get an idea about the classification of second order PDE. 3. Learn about the solutions of three important type of PDE's namely heat equation, wave equation and Laplace equation.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.

Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT03DSE1 FUZZY MATHEMATICS

Course code & Title	**MSMAT03DSE1 FUZZY MATHEMATICS**
Course objectives	The aim is to provide an introduction to the fundamental concepts of Fuzzy Mathematics.

Module	**Content**	**Module Outcome**
I (15 Hours)	From classical (crisp) sets to fuzzy sets: characteristics and significance of the paradigm shift. Additional properties of α-cuts. Representation of fuzzy sets. Extension principle for fuzzy sets. (Chs. 1 & 2 of the Text Book)	Students will be able to comprehend the similarities and distinctions between crisp sets and fuzzy sets
II (15 Hours)	Operations on fuzzy sets. Types of operations. Fuzzy complements. t-norms, t-conorms. Combinations of operations. Aggregate operations. , Fuzzy numbers Arithmetic operations on intervals. Arithmetic operations on fuzzy numbers. Lattice of fuzzy numbers (Sections 3.1 to 3.4 of Ch. 3 of the Text and sections 4.1 to 4.5)	Students will develop an understanding of the fundamental concepts of union and intersection within fuzzy sets, enabling them to effectively navigate the nuances of set operations in fuzzy environments. Additionally, they will grasp the concept of fuzzy numbers and their arithmetic operations, allowing them to manipulate and interpret fuzzy data with confidence and accuracy.
III (15 Hours)	Crisp and fuzzy relations, projections and cylindric extensions, binary fuzzy relations, binary relations on a single set, Fuzzy equivalence relations , Compatibility and ordering relations.Fuzzy morphisms. sup-i, inf- ωicompositions of fuzzy relations. (sections 5.1 to5.6 and sections 5.8 to 5.10 of chapter 5 of text 5)	Students will gain a comprehensive understanding of the concept of fuzzy relations, including an exploration of various types of fuzzy relations and the operations involved in manipulating them

IV (15 Hours)	Fuzzy logic. Fuzzy propositions. Fuzzy quantifiers. Linguistic hedges. Inference from conditional, conditional and qualified and quantified propositions (Chapter . 8 of the Text)	This section aims to provide students with insight into the limitations of classical two-valued logic in addressing the imprecision, uncertainty, and complexity inherent in the real world. It also introduces the concepts of multi-valued logic and fuzzy logic, offering a broader perspective on handling such complexities effectively.

References	**TEXT BOOK:** Fuzzy sets and Fuzzy logic Theory and Applications – G. J. Klir & Bo Yuan – PHI (1995) **REFERENCES :** 1. Zimmermann H. J. – Fuzzy Set Theory and its Applications, Kluwer (1985) 2. Zimmermann H. J. – Fuzzy Sets, Decision Making and Expert Systems, Kluwer (1987) 3. Dubois D. & H. Prade – Fuzzy Sets and Systems: Theory and Applications – Academic Press (1980)

Course Outcome	**After successful completion of this course, students will be able to:**
	1. Students will be able to comprehend the similarities and distinctions between crisp sets and fuzzy sets 2. Students will gain insight into the concepts of union and intersection within fuzzy sets, as well as grasp the notion of fuzzy numbers and their arithmetic operations 3. Students will gain a comprehensive understanding of the concept of fuzzy relations, including an exploration of various types of fuzzy relations and the operations involved in manipulating them 4. Students will get an insight into the limitations of classical two-valued logic in addressing the imprecision, uncertainty, and complexity inherent in the real world. 5. Will get the concepts of multi-valued logic and fuzzy logic, offering a broader perspective on handling complexities like imprecision, uncertainty etc. effectively.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT03DSE2 OPERATIONS RESEARCH

Course code & Title	**MSMAT03DSE2 OPERATIONS RESEARCH**
Course objectives	The course aims: Identify and develop the mathematical tools that are needed to solve optimization problems.

Module	**Content**	**Module Outcome**
I (15 Hours)	Linear programming in two-dimensional spaces. General LP problem. Feasible, basic and optimal solutions, simplex method, simplex tableau, finding the first basic feasible solution, degeneracy, simplex multipliers. (Chapter 3 Sections 1-15).	Students will able to solve two dimensional LPP problems
II (15 Hours)	The revised simplex method. Duality in LP problems, Duality theorems, Applications of duality, Dual simplex method, summary of simplex methods, Applications of LP. (Chapter 3. Sections 16-22)	Will get a sound knowledge in the Revised Simplex Method,which refines the traditional Simplex Method by incorporating additional techniques to handle degeneracy and numerical precision, thereby enhancing its performance in solving linear programming problems.
III (15 Hours)	Transportation and Assignment problems (Chapter 4)	Students will able to solve the transportation and assignment problems ,special cases of linear programming problems and can be solved using optimization techniques such as the simplex method, network flow algorithms, or specialized algorithms tailored to their specific structures

IV (15 Hours)	Integer programming. Theory of games (Chapters 6 and 12)	Will get a brief introduction on how to Solve Integer Programming problems. This is generally more challenging than solving linear programming problems because the feasible solution space is discrete rather than continuous. Traditional optimization techniques like the simplex method are not directly applicable to integer programming. Instead, specialized algorithms such as branch and bound, cutting plane methods, and mixed integer programming solvers are used to find optimal or near-optimal solutions. Also get an introduction about game theory ,a branch of mathematics that studies about strategic decision-making in situations where the outcome of an individual's choice depends on the choices of others.

References	**TEXT BOOK:** K. V. Mital and C. Mohan – Optimisation Methods in Operations Research and Systems Analysis (3rd edition) -New Age International (1996). **REFERENCE BOOKS:** 1. Wagner – Operations Research, Prentice Hall India 2. A. Ravindran, Don T. Philips, James Solberg – Operations Research, Principles and Practice – John Wiley (3rd edition) 3. G. Hadley – Linear Programming – Addison Wesley 4. Kanti Swarup, P.K.gupta, Man Mohan – Operations Research – S. Chand & Co.

Course Outcome	**After successful completion of this course, students will be able to:**
	1. Students will able to solve two dimensional LPP problems 2. Will get a sound knowledge in the Revised Simplex Method 3. Students will able to solve the transportation and assignment problems 4. Will get a brief introduction on how to Solve Integer Programming problems. 5. Will get an introduction about game theory ,a branch of mathematics that studies about strategic decision-making in situations where the outcome of an individual's choice depends on the choices of others.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT03DSE3 STOCHASTIC PROCESSES

Course code & Title	**MSMAT03DSE3 STOCHASTIC PROCESSES**
Course objectives	The course aims:The aim is to provide an introduction to the fundamental concepts of stochastic process**.**

Module	**Content**	**Module Outcome**
I (15 Hours)	A brief description of Markov Process, Renewal Process, Stationary Process. Markov Chains: n-step transition probability matrix, classification of states, canonical representation of transition probability matrix, finite Markov chains with transient states. Irreducible Markov Chains with ergodic states: Transient and limiting behaviour.	Students will get an introduction to Markov Processes, which provides a simple yet powerful framework for modeling and analyzing systems with probabilistic behavior, making them a fundamental tool in probability theory and stochastic
II (15 Hours)	First passage and related results. Branching Processes and Markov chains of order larger than 1, Lumpable Markov Chains, Reversed Markov Chains	Students will get a basic knowledge about branching processes and Markov chains. Both are fundamental tools in probability theory and have wide-ranging applications in various fields, including biology, epidemiology, economics, and computer science
III (15 Hours)	Applied Markov Chains: Queuing Models, Inventory Systems, Storage models, Industrial Mobility of Labour,, Educational Advancement, Human Resource Management, Term Structure, Income determination under uncertainty, Markov decision process. Markov Processes: Poisson and Pure birth processes, Pure death processes, Birth and death processes, Limiting distributions.	Able to learn how Markov chains are applied in various fields to model, analyze, and make predictions about systems with probabilistic behavior. Applied Markov Chains play a crucial role in understanding complex systems and making informed decisions in diverse domains.

IV (15 Hours)	Markovian Networks. Applied Markov Processes: Queueing models, Machine interference problem, Queueing networks, Flexible manufacturing systems, Inventory systems, Reliability models, Markovian Combat models, Stochastic models for social networks; Recovery, relapse and death due to disease.	Will able to understand about Markovian Networks, which provide a flexible framework for modeling complex dependencies among random variables in a wide range of applications, enabling probabilistic reasoning, inference, and learning in complex systems

References	**<u>TEXT BOOK</u>:** U.N. Bhat and Gregory Miller: Elements of Applied Stochastic Processes, Wiley Interscience, 2002 (Chs. 1, 2, 3, 4, 6, 7, 9.1-9.4, 9.9 and 10) **<u>REFERENCES:</u>** 1. Karlin and Taylor: A First Course in Stochastic Processes, Academic Press, 1975 2. 2.E.Parzen: Stochastic Processes, Wiley 1968. 3. J.Medhi: Introduction to Stochastic Processes, New Age International Publishers, 1994, Reprint 1999.

Course Outcome	After successful completion of this course, students will be able to:
	1. Students will get an introduction to Markov Processes 2. Students will get a basic knowledge about branching processes and Markov chains, both are fundamental tools in probability theory 3. Able to learn, how Markov chains are applied in various fields to model, analyze, and make predictions about systems with probabilistic behavior. 4. Able to understand about Markovian Networks, which provide a flexible framework for modeling complex dependencies among random variables in a wide range of applications 5. Able to learn how Markov chains are applied in various fields to model, analyze, and make predictions about systems with probabilistic behavior. 6. Will able to understand about Markovian Networks, which provide a flexible framework for modeling complex dependencies among random variables in a wide range of applications

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT03MDC1 CALCULUS WITH AN INTRODUCTION TO LINEAR ALGEBRA

Course code & Title	**MSMAT03MDC1 CALCULUS WITH AN INTRODUCTION TO LINEAR ALGEBRA**
Course objectives	The aim of the course is to provide students with a comprehensive understanding of fundamental calculus concepts and techniques, enabling them to apply calculus principles to solve real-world problems and prepare for advanced studies in mathematics and related fields

Module	**Content**	**Module Outcome**
I (15 Hours)	Some concepts of integral calculus: The basic ideas of Cartesian geometry, Functions. Informal description and examples ,Functions. Formal definition as a set of ordered pairs, More examples of real functions, The concept of area as a set function, Intervals and ordinate sets, Partitions and step functions, Sum and product of step functions, The definition of the integral for step functions, Properties of the integral of a step function, Other notations for Integrals, The integral o fmore general functions, Upper and lower integrals, The area of an ordinate set expressed as an integral , Informal remarks on the theory and technique of integration, Monotonic and piecewise monotonic functions. Definitions and examples, Integrability of bounded monotonic functions , Calculation of the integral of a bounded monotonic function, Calculation of the integral fx dx when p is a positive integer, The basic properties of the integral, Integration of polynomials, Introduction, The area a region between two graphs expressed as an integral. (Sections 1.1 to 1.26 of chapter 1 of text 1, Sections 2.1 and 2.2 of chapter 2 of Text 1)	1. Students will gain a deep understanding of continuity, including its informal description and formal definition in terms of limits. They will grasp the concept of limits of functions and its role in determining the behavior of functions at certain points. 2. Students will become proficient in identifying and analyzing continuous functions, including recognizing more examples of continuous functions. They will also master basic limit theorems and understand their applications in evaluating limits and continuity. 3. Students will learn to apply continuity concepts in various theorems such as Bolzano'stheorem, the intermediate-value theorem, and the extreme-value theorem for continuous functions. They will also explore properties preserved by inversion and understand the significance of piecewise monotonic functions in this context. 4.Students will master advanced concepts and theorems related to continuous functions, including the small-span theorem (uniform continuity), the integrability theorem, and mean-value theorems for integrals. They will be able to apply these theorems in solving problems involving continuous functions and their integrals.

II (15 Hours)	Continuous Functions: Informal description of continuity, The definition of the limit of a function, The definition of continuity of a function, The basic limit theorems. More examples of continuous functions ,Composite functions and continuity, Bolzano theorem for continuous functions, The intermediate-value theorem for continuous functions, The process of inversion, Properties of functions preserved by inversion, Inverses of piecewise monotonic functions, The extreme-value theorem for continuous functions, The small-span theorem for continuous functions (uniform continuity), The integrability theorem for continuous functions, Mean-value theorems for integrals of continuous functions . (Sections 3.1 to 3.20(excluding section 3.5) of chapter 3 of text 1)	1: Students will understand the fundamentals of continuity and limits, including the informal concept of continuity, definition of limits, continuity of functions, and basic limit theorems. 2: Students will explore advanced concepts in continuity, such as analyzing composite functions, Bolzano's theorem, and the intermediate-value theorem. 3: Students will learn about inversion processes, properties of functions preserved by inversion, inverses of piecewise monotonic functions, and their applications in mathematics and related fields.

III (15 Hours)	Differential Calculus: Historical introduction, A problem involving velocity, The derivative of a function, Examplesof derivatives, The algebra of derivatives, Geometric interpretation of the derivative as a slope, Other notations for derivatives, The chain rule for differentiating composite functions, The mean-value theorem for derivatives, Applications of the chain rule. Related rates and implicit differentiation, Applications of differentiation to extreme values of functions, Applications of the mean-value theorem to geometric properties of functions, Second-derivative test for extrema, Curve sketching. (Sections 4.1 to 4.19 of chapter 4 of Text 1)	1: Students will grasp the historical context of differentiation and its application in solving velocity problems, gaining insight into its evolution and significance. 2: Students will master differentiation techniques, including the algebra of derivatives and geometric interpretations, enabling them to compute derivatives efficiently and interpret their meaning graphically. 3: Students will apply differentiation tools such as the chain rule and the mean-value theorem to solve real-world problems, particularly in related rates and implicit differentiation scenarios. 4: Students will utilize differentiation to analyze extreme values, employ the second derivative test, and sketch curves accurately, enhancing their ability to understand and communicate the behavior of functions.

IV (15 Hours)	Linear spaces, Linear transformations and Matrices: Introduction, The definition of a linear space, Examples of linear spaces, Elementary consequences of the axioms, Subspaces of a linear space, Dependent and independent sets in a linear space, Bases and dimension, Inner products, Euclidean spaces, norms, Orthogonality in a Euclidean space, Construction of orthogonal sets. The Gram-Schmidt process, Orthogonal complements. Projections, Linear transformations, Null space and range, Nullity and rank, Algebraic operations on linear transformations, Inverses, One-to-one linear transformations, Linear transformations with prescribed values, Matrix representations of linear transformations , Construction of a matrix representation in diagonal form, Linear spaces of matrices, Isomorphism between linear transformations and matrices, Multiplication of matrices, Systems of linear equations, Computation Techniques, Inverses of Square matrices . (Sections 15.1 to 15.14 and Sections 16.1 to 16.21 of chapters 15 and 16 of text1.)	1: Students will comprehend the foundational concepts of linear spaces, including their definition, subspaces, and dependent/independent sets, laying the groundwork for advanced studies in linear algebra. 2: Students will master Euclidean spaces, inner products, norms, and orthogonality, enabling them to analyze geometric properties and relationships within vector spaces efficiently. 3: Students will develop proficiency in linear transformations, including null space, range, nullity, and rank, as well as constructing matrix representations and performing algebraic operations on linear transformations. 4: Students will achieve competence in matrix operations, solving systems of linear equations, and understanding isomorphisms between linear transformations and matrices, equipping them with essential skills for practical applications in mathematics and related fields.

References	**Text book**: (1) Tom M. Apostol-Calculus. Vol. I : One Variable Calculus with an Introduction to Linear Algebra(2 nd Edition), Wiley. **Reference Books** : (1) Tom M. Apostol -Calculus. Vol. II : Multi-Variable Calculus and Linear Algebra, with Applications to Differential Equations and Probability,(2 nd Edition), Wiley. (2)Anton,Bivens, Davis - Calculus(7 th Edition), Wiley. (3)Kenneth Hoffman, Ray Kunze -Linear Algebra(2 nd Edition), Prentice Hall. (4)Seymour Lipschutz, Marc Lipson-Linear Algebra(3 rd Edition), McGraw-Hill. (5)Robert C. Wrede, Murray Spiegel-Advanced Calculus(2 nd Edition), McGraw-Hill.

Course Outcome	After successful completion of this course, students will be able to:
	1: Gain a foundational understanding of integral calculus concepts, including Cartesian geometry, functions, and area computation, preparing them for further studies in calculus. 2: Develop proficiency in analyzing and manipulating continuous functions, applying limit theorems, and understanding properties preserved by inversion, bolstering their problem-solving skills in calculus. 3: Master differentiation techniques, including the chain rule and mean-value theorems, and learn to apply them to solve problems involving extreme values and geometric properties of functions, enhancing their ability to analyze functions graphically. 4: Achieve competence in linear algebra concepts, such as linear spaces, transformations, and matrices, enabling them to solve systems of linear equations and analyze properties of linear spaces and transformations effectively.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video),Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.

Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

FOURTH SEMESTER M.Sc. MATHEMATICS PROGRAMME

SCHEME

FOURTH SEMESTER								
Course Code	Title of Course	Contact Hours/Week			Marks			
		L	T/S	P	ESE	CE	Total	Credit s
DISCIPLINE-SPECIFIC CORE COURSE								
MSMAT04DSC13	DISSERTATION AND VIVA VOCE		5		120	80	200	8
DISCIPLINE-SPECIFIC ELECTIVE COURSES (Choose Four)								
MSMAT04DSE4	ADVANCED COMPLEX ANALYSIS	4	1		60	40	100	4
MSMAT04DSE5	ADVANCED TOPICS IN ANALYSIS	4	1		60	40	100	4
MSMAT04DSE6	ALGEBRAIC GEOMETRY	4	1		60	40	100	4
MSMAT04DSE7	ALGEBRAIC NUMBER THEORY	4	1		60	40	100	4
MSMAT04DSE8	ALGEBRAIC TOPOLOGY	4	1		60	40	100	4
MSMAT04DSE9	ANALYTIC NUMBER THEORY	4	1		60	40	100	4
MSMAT04DSE10	CRYPTOGRAPHY	4	1		60	40	100	4
MSMAT04DSE11	CODING THEORY	4	1		60	40	100	4
MSMAT04DSE12	GRAPH THEORY	4	1		60	40	100	4
MSMAT04DSE13	HARMONIC ANALYSIS	4	1		60	40	100	4
MSMAT04DSE14	LIE ALGEBRA AND REPRESENTATIO N THEORY	4	1		60	40	100	4

MSMAT04DSE15	**NUMBER THEORY**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT04DSE16	**NUMERICAL ANALYSIS AND COMPUTING**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT04DSE17	**OPERATOR ALGEBRAS**	**4**	**1**		**60**	**40**	**100**	**4**
MSMAT04DSE18	**REPRESENTATION THEORY OF FINITE GROUPS**	**4**	**1**		**60**	**40**	**100**	**4**
	Total	**16**	**9**		**360**	**240**	**600**	**24**

Note: -L:Lecture ,T/S :Tutorial/Seminar, P :Practical ,ESE : End Semester Evaluation, CE Continuous Evaluation

DISCIPLINE-SPECIFIC CORE COURSE

MSMAT04DSC13 DISSERTATION AND VIVA VOCE

Each Master of Science student is required to undertake a minor research project during the fourth semester, with the project work amounting to 8 credits. Evaluation of the project will occur at the end of the fourth semester, encompassing both internal (totaling 80 marks) and external assessments (totaling 120 marks). The evaluation scheme for the project is outlined as follows:

Total marks : 200

Content : 30% = 60 marks (36 external & 24 internal)

Methodology and presentation : 50% = 100 marks (60 external & 40 internal)

Dissertation Viva-voce : 20 % = 40 marks (24 external & 16 internal)

The external evaluation of the project will be conducted by a board of examiners, consisting of two External Examiners along with the Chairman of the Board of Examiners.

DISCIPLINE-SPECIFIC ELECTIVE COURSES

MSMAT04DSE4 ADVANCED COMPLEX ANALYSIS

Course code & Title	**MSMAT04DSE4 ADVANCED COMPLEX ANALYSIS**
Course objectives	The course aims: The aim of the course is the study some advanced topics in complex analysis like Hadamard's theorem, reflection principle, mean value property, elliptic functions, The Weierstrass ρ-function etc.

Module	**Content**	**Module Outcome**
I (15 Hours)	Partial fractions. Infinite products. Canonical products. The Gamma function. Stirling's formula. Entire functions. Jensen's fomula. Hadamard's theorem (without proof) (Chapters 5, section 2)	1.Students Will able to decompose rational functions into partial fractions ,which is crucial for various applications in complex analysis, including integration, series expansions, and solving differential equations. 2.Will get a thorough knowledge in Canonical products, which are a specialized form of infinite products that arise in the study of entire and meromorphic functions
II (15 Hours)	Riemann mapping theorem. Boundary behaviour. Use of reflection principle. Analytic arcs. Conformal mapping of polygons. The Schwarz-Christoffel formula. Mapping on a rectangle. The triangle functions of Schwarz. Functions with mean value property. Harnack's principle (Ch. 6 Sections 1,2,3)	1.Will get a good knowledge about the Riemann mapping theorem, which is crucial in complex analysis. 2.Will have a good understanding in the reflection principle, which is a powerful tool in complex analysis used to extend analytic functions across certain boundaries by exploiting symmetry properties

III (15 Hours)	Subharmonic functions. Solutions. Solution of Dirichlet problem . Simply periodic functions. Doubly periodic functions. Unimodular transformations. Canonical basis. General properties of elliptic functions. (Ch. 6 Sections ,4 and Chapter 7 sections 1,2)	1.Will get a thorough knowledge about the subharmonic functions, which play a crucial role in complex analysis, potential theory, and partial differential equations. 2.Will get an understanding about the existence and uniqueness of solutions to certain differential equations and boundary value problems, which is a fundamental aspect of complex analysis
IV (15 Hours)	The Weierstrass ρ-function. The functions ζ(z) and σ(z). The modular function λ(τ). Conformal mapping by λ(τ). Analytic continuation. Germs and sheaves. Sections and Riemann surfaces. Analytic continuations along arcs. Monodromy theorem.. (Ch. 7, section 3 and Chapter 8 section up to and including 1.6)	1.Will get a good knowledge about the Weierstrass ρ-function, which is a meromorphic function used in the construction of elliptic functions. 2. Get a thorough knowledge about analytic continuation, which provides students with techniques for extending the applicability of analytic functions and understanding their global behaviour.

References	**Text Book:** Ahlfors L. V. – Complex Analysis (3rd edition) McGraw Hill International. **References:** 1. Conway J. B. – Functions of one complex variable – Narosa (2002) 2. Lang S.– Complex Analysis – Springer (3rd edn.) (1995) 3. Karunakaran, V. – Complex Analysis – Alpha Science International Ltd. (2nd edn.) 2005

Course Outcome	After successful completion of this course, students will be able to:
	1.Studying this course equips students with advanced tools and techniques in complex analysis, enabling them to analyze and understand a wide range of functions and phenomena in mathematics and related fields. 2. Studying this course equips students with advanced techniques for solving complex analytic problems, understanding the behaviour of analytic functions, and applying complex analysis in various mathematical and applied contexts. 3.Studying this course equips students with advanced tools and techniques for analyzing complex functions, solving differential equations, and understanding the rich mathematical structures that arise in complex analysis, particularly in the context of periodic and elliptic functions. 4. Studying thi equips students with advanced techniques and concepts in complex analysis, enabling them to explore the rich interplay between analytic functions, Riemann surfaces, and algebraic geometry. 4.Studying this course equips students with advanced techniques and concepts in complex analysis, enabling them to explore the rich interplay between analytic functions, Riemann surfaces, and algebraic geometry.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE5 ADVANCED TOPICS IN ANALYSIS

Course code & Title	MSMAT04DSE5 ADVANCED TOPICS IN ANALYSIS
Course objectives	There are 2 main objectives for this course: 1. To get an overall knowledge on basic analysis which helps to do further advanced reading in this direction. 2. It touches the fundamental areas of measure theory, point set topology and Lebesgue spaces so that students get a connection with various tools used in advanced analysis.

Module	Content	Module Outcome
I (20 Hours)	Unit I: Signed measures: 1.1 Review of measures and integration 1.2 Signed measures 1.3 The Lebesgue-Radon-Nikodym theorem Chapter 1 and 2 review, chapter 3, Sections - 3.1 - 3.3.	The main aim of this module is to understand the Lebesgue-radon-Nikodym theorem
II (10 Hours)	Unit 2: Differentiation: 2.1 Complex measures 2.2 Differentiation on Euclidean space 2.3 Functions of bounded variation Chapter 3, Sections 3.3 -3.5	This module is intended to make students comfortable about complex measures and functions of bounded variation

III (15 Hours)	Unit 3: Point set topology: 3.1 Topological spaces 3.2 Continuous maps 3.3 Nets 3.4 Compact Spaces 3.5 Locally compact Hausdorff spaces 3.6 Two compactness theorems 3.7 The Stone-Weiersrtrass theorem Chapter 4, Sections 4.1 - 4.7	This module uses the knowledge the students in basic point set topology and deals with the locally compact Hausdorff spaces and The Stone-Weiersrtrass theorem.
IV (15 Hours)	Unit 4: Lebesgue Spaces: 4.1 Basic theory of Lp spaces 4.2 The dual of Lp 4.3 Some useful inequalities 4.4 Distribution function and weak Lp 4.5 Interpolation of Lp spaces Chapter 6 - Section 6.1 - 6.5	This module is dealing with Lp spaces mainly. It is expected that after the completion of this module students would be comfortable with the some important inequalities, basics of distribution and interpolation.

References	**TEXT BOOK:** Real Analysis: Modern Techniques and Their Applications by Gerald B. Folland, Second edition, John Willey and Sons, Inc, 1999 **REFERENCES :** 1. Foundations of Real and Abstract Analysis by D. S. Bridges, GTM Series, Springer Verlag 1997 2. Real and Complex Analysis by W. Rudin, Tata McGr

Course Outcome	**After successful completion of this course, students will be able to:**
	1. Be proficient in basic measure and integration theory.
	2. Learn about the signed measures, complex measures and functions of bounded variation.
	3. Get comfortable with basic point set topology and learn some advanced topics in locally compact Hausdorff spaces
	4. Learn Lebesgue spaces and some important analytic aspects of them

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40

Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE6 ALGEBRAIC GEOMETRY

Course code & Title	MSMAT04DSE6 ALGEBRAIC GEOMETRY
Course objectives	The course aims: The purpose of this course is to teach some basic principles of algebraic geometry.

Module	Content	Module Outcome
I (15 Hours)	Affine algebraic varieties. The Zariski topology. Morphisms. Dimension. Hilbert basis theorem. Hilbert Nullstellensatz. The co-ordinate ring. The spectrum of a ring.	1.Students learn about sets of solutions to polynomial equations, known as algebraic varieties, and particularly focus on affine algebraic varieties, which are defined by polynomial equations in affine space 2. Students become familiar with the Zariski topology, a key concept in algebraic geometry that describes the open sets in the topology of affine algebraic varieties
II (15 Hours)	Projective space. Projective varieties. Projective closure. Morphisms of projective varieties. Automorphisms of projective space. Quasi-projective varieties. A basis for the Zariski topology. Regular functions.	Students will able to deepen their understanding of algebraic geometry and also enhance their problem-solving skills and ability to analyse geometric structures in projective space
III (15 Hours)	Classical constructions.	They learn to apply algebraic techniques to study geometric objects and gain insights into the connections between algebra and geometry, laying the foundation for further study in advanced topics in algebraic geometry

IV (15 Hours)	Smoothness. Bertini's theorem. The Gauss mapping	1.Students will learn about smooth points, singular points, and the importance of regularity in algebraic geometry. 2.Will gain insight into probabilistic methods in algebraic geometry and learn how to use probabilistic techniques to study geometric properties. 3. Will able to understand the geometric significance of the Gauss mapping and its applications in differential geometry and algebraic geometry.

References	**TEXT BOOK:** An invitation to Algebraic Geometry – K. Smith, L. Kahanpaa, P. Kekalainen and W. Treves, Springer (2000) relevant portions of Chapters 1 to 7. **References**: 1. Undergraduate Commutative Algebra – Miles Reid, Cambridge Univ. Press. (1995) 2. Introduction to Commutaive Algebra – M. F. Atiyah & I. G. MacDonald – Addison-Wesley (1969) 3. Algebraic Geometry – Keith Kendig – Springer 4. Undergraduate Algebraic Geometry – Miles Reid, Cambridge Univ. Press (1988) 5. Hartshorne, R. – Algebraic Geometry, Springer-Verlag (1977) 6.Shafarevich I. R. – Basic Algebraic Geometry, Springer-Verlag (1974).

Course Outcome	After successful completion of this course, students will be able to:
	1.Students learn about sets of solutions to polynomial equations, known as algebraic varieties, and particularly focus on affine algebraic varieties, which are defined by polynomial equations in affine space 2. Students become familiar with the Zariski topology, a key concept in algebraic geometry that describes the open sets in the topology of affine algebraic varieties 3.Students will able to deepen their understanding of algebraic geometry and also enhance their problem-solving skills and ability to analyse geometric structures in projective space 4.They learn to apply algebraic techniques to study geometric objects and gain insights into the connections between algebra and geometry, laying the foundation for further study in advanced topics in algebraic geometry. 5.Students will learn about smooth points, singular points, and the importance of regularity in algebraic geometry. 6.Will gain insight into probabilistic methods in algebraic geometry and learn how to use probabilistic techniques to study geometric properties. 7. Will able to understand the geometric significance of the Gauss mapping and its applications in differential geometry and algebraic geometry.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.

Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE7 ALGEBRAIC NUMBER THEORY

Course code & Title	**MSMAT04DSE7 ALGEBRAIC NUMBER THEORY**
Course objectives	The aim is to provide a gentle introduction to the fundamental concepts of algebraic number theory.

Module	**Content**	**Module Outcome**
I (15 Hours)	Algebraic background, Symmetric Polynomials, modules, Free abelian groups, Algebraic numbers, Conjugates and discriminants, algebraic integers, integral basis, norms and traces, Rings of integers.(Sections 1.4-1.6, 2.1-2.6 of the text book)	Students will get a basic introduction and motivation into the subject.
II (15 Hours)	Quadratic fields. Cyclotomic fields. Factorization into irreducible: Historical back ground. Trivial factorization int irreducible (Sections 3.1, 3.2, 4.1-4.3 of the text book)	Historical background and basics of quadratic fields, cyclotomic fields and concepts of factorization is discussed.
III (15 Hours)	Examples of non-unique factorization into irreducible. Prime factorization, Euclidean domains, Euclidean quadratic fields. Congruences of unique factorization Ramanujan-Nagell theorem. (Sections 4.4-4.9 of the text book)	Knowledge of unique and non unique factorizations, prime factorization and Euclidean quadratic fields are attained.
IV (15 Hours)	Ideals, Historical background, Prime factorization of ideals. The norm of an ideal. Non-unique factorization in cyclotomic fields. Lattices. The quotient torus. (Sections 5.1-5.4, 6.1, 6.2 of the text book)	Knowledge of ideals, prime factorization, factorization in cyclotomic fields, lattices are obtained.

References	**<u>TEXT BOOK:</u>** **Text Book:**1.N.Stewart & D.O.Tall- Algebraic Number Theory (2nd edn.) Chapman & Hall (1987) **<u>REFERENCES</u> :** 1. P.Samuel- Theory of Algebraic numbers-Herman Paris Houghton Mifflin (1975) 2. S Lang-Algebraic Number Theory- Addison Wesley (1970)

Course Outcome	**After successful completion of this course, students will be able to:**
	The students can learn how to apply abstract algebraic techniques to understand theory of integers, rational numbers and their generalizations.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE8 ALGEBRAIC TOPOLOGY

Course code & Title	**MSMAT04DSE8 ALGEBRAIC TOPOLOGY**
Course objectives	The course aims: The course discusses simplicial homology theory, the Euler Poincare theorem and the fundamental group. The purpose of this course is to give students the opportunity to see how algebraic concepts or abstract algebra can be used as a tool to learn topology, another branch of mathematics

Module	**Content**	**Module Outcome**
I (15 Hours)	Geometric complexes and polyhedra. Orientation of geometric complexes.	The students will grasp how Algebraic Topology elucidates the structure of a topological space by correlating it with algebraic systems, particularly groups.
II (15 Hours)	Simplicial homology groups. Structure of homology groups. The Euler-Poincare theorem. Pseudomanifolds and the homology groups of Sn.	Students will gain an understanding of homology groups.
III (15 Hours)	Simplicial approximation. Induced homomorphisms on homology groups. Brouwer fixed point theorem and related results	In this section, students will learn to compare two topological spaces based on the algebraic similarities between their associated homology groups.
IV (15 Hours)	The fundamental groups. Examples. The relation between H1(K) and π1(|K|).	In this unit, students will comprehend how the structure of two topological spaces can be explored through the analysis of paths within those spaces.

References	**Text Book:** Fred H. Croom – Basic Concepts of Algebraic Topology – Springer Verlag (1978) **References:** 1) Maunder – Algebraic Topology – Van Nostrand-Reinhold (1970) 2) Munkres J.R. – Topology, A First Course – Prentice Hall (1975) 3) Allen Hatcher-Algebraic Topology Cambridge University Press 2002

Course Outcome	**After successful completion of this course, students will be able to:**
	1. The students will grasp how Algebraic Topology elucidates the structure of a topological space by correlating it with algebraic systems, particularly groups. 2. Able to gain an understanding of homology groups. 3. Will able to compare two topological spaces based on the algebraic similarities between their associated homology groups. 4. Able to comprehend how the structure of two topological spaces can be explored through the analysis of paths within those spaces.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.

Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE9 ANALYTIC NUMBER THEORY

Course code & Title	**MSMAT04DSE9 ANALYTIC NUMBER THEORY**
Course objectives	The aim of this course is to provide an introduction to analytic number theory. Prime number theorem and Dirichlet's theorem on primes in arithmetic progressions are discussed.

Module	**Content**	**Module Outcome**
I (15 Hours)	The Fundamental theorem of Arithmetic, Arithmetical functions and Dirichlet multiplications.	Students understands the fundamental theorem of arithmetic there by understanding prime numbers. Arithmetical functions like divisor functio, Euler totient functions and their Dirichlet product is discussed.
II (15 Hours)	Averages of arithmetical functions. Some elementary theorems on the distribution of prime numbers.	Averages of arithmetical functions is studied. Chebyshev function is introduced and its relation with prime number distribution is discussed. Main outcome of this chapter is the understanding of the famous prime number theorem.
III (15 Hours)	Congruences, Finite abelian groups and their characters.	The congruence relation between numbers is discussed and the famous Euler – Fermat theorem is studied. Some group theoretical aspects of finite abelian groups and their characters are studied in the perspective of number theory.

IV (15 Hours)	Dirichlet's theorem on primes in arithmetic progressions. Periodic Arithmetical Functions and Gauss sums	The Dirichlet theorem of infiniteness of prime n umbers in discussed. Periodicity of arithmetic functions and the Gauss sum of a Dirichlet character is studied.

References	**TEXT BOOK:** Tom M. Apostol - Introduction to Analytic Number Theory (Springer International Edn. 1998) Relevant portions from Chapters 1-8. **REFERENCES :** 1. G.H.Hardy & Wright Introduction to Theory of Numbers (Oxford) 1985 2. H.Davenport- The Higher Arithmetic (Cambridge) (6th edn.) 1992.

Course Outcome	**After successful completion of this course, students will be able to:**
	Students can understand the basic and fundamental topics like arithmetic functions, Dirichlet product of arithmetic functions, congruence relations, study of abelian groups via congruences, chinese reminder theorem etc. The main goal is the understanding of the famous prime number theorem in number theory explaining the infiniteness and distribution of prime numbers.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE10 CRYPTOGRAPHY

Course code & Title	**MSMAT04DSE10 CRYPTOGRAPHY**
Course objectives	The course aims: The aim is to provide an introduction to the fundamental concepts of Cryptography

Module	Content	Module Outcome
I (15 Hours)	Classical cryptography. Some simple cryptosystems. Cryptanalysis (Chapter 1 of the Text)	1. Students learn fundamental principles of encryption, such as substitution and transposition, which form the basis of classical cryptosystems 2. They learn how to break classical ciphers and uncover the plaintext without knowledge of the key. 3. Through practical exercises and assignments, students get hands-on experience implementing and analyzing classical cryptosystems

II (15 Hours)	Shannon's theory (Ch. 2)	1. Students gain a solid understanding of information theory, particularly concepts such as entropy, redundancy, and uncertainty 2. The study of Shannon's theory familiarizes students with key cryptographic concepts, including the distinction between secrecy and security, the role of keys in encryption, and the importance of randomness in generating secure keys and ciphertext
III (15 Hours)	Block ciphers and the advanced encryption standard (Ch. 3)	1. Students learn about the security features incorporated into AES, such as confusion and diffusion, resistance against various cryptanalytic attacks including differential and linear cryptanalysis, and the importance of key length in ensuring security. 2. They acquire the knowledge and skills necessary to design, analyze, and implement secure cryptographic systems based on block ciphers.

IV (15 Hours)	Cryptographic hash function. (Ch. 4)	1. Students gain a comprehensive understanding of cryptographic hash functions, including their definition, properties, and key characteristics. 2. Students gain insight into hash functions as cryptographic primitives and their role in constructing more complex cryptographic constructions. 3. Students learn about cryptanalysis techniques applicable to cryptographic hash functions, including birthday attacks, collision attacks, and length extension attacks.

References	**<u>Text book:</u>** Cryptography, Theory and Practice – Douglas R. Stinson – Chapman & Hall (2002) **<u>References:</u>** 1. N. Koblitz – A Course in Number Theory and Cryptography (2nd edition) Springer Verlag (1994) 2. D.R.Hankerson etc. – Coding Theory and Cryptography The Essentials – Marcel Dekker

Course Outcome	After successful completion of this course, students will be able to:
	1. Studying this course provides students with a comprehensive introduction to the principles, techniques, and challenges of cryptography, laying the groundwork for further exploration in this fascinating field. 2. Studying this course fosters a deeper understanding of the theoretical underpinnings of cryptography and prepares students for both academic pursuits and real-world applications in cybersecurity. 3. Studying this course will give a thorough knowledge about t block ciphers and the Advanced Encryption Standard ,which equips students with essential knowledge and skills in symmetric cryptography, enabling them to understand, analyze, and implement secure encryption solutions in practice. 4. Studying this course will give a good insight into t cryptographic hash functions, which equips students with foundational knowledge and practical skills in modern cryptography, enabling them to understand, analyze, and apply hash functions in various cryptographic applications and security-critical systems.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE11 CODING THEORY

Course code & Title	**MSMAT04DSE11 CODING THEORY**
Course objectives	The course aims: The aim is to provide an introduction to the fundamental concepts of coding theory

Module	Content	Module Outcome
I (15 Hours)	Introduction to Coding Theory. Correcting and detecting error patterns. Weight and distance. MLD and its reliability. Error-detecting codes. Error correcting codes. Linear codes (Chapter 1 of the Text and sections 2.1 to 2.5 of chapter 2 of the text)	By studying these concepts empowers students ,to design, analyse, and implement error-correcting codes for reliable communication systems. They develop problem-solving skills, mathematical reasoning abilities, and a deep understanding of the principles underlying modern digital communication technology.
II (15 Hours)	Generating matrices and encoding. Parity check matrices. Equivalent codes. MLD for linear codes. Reliability of IMLD for linear codes , Some bounds for codes,Perfect codes , Hamming codes. Extended codes extended Golay code and Decoding of extended Golay code (Sections 2.6 to 2.12 of Chapter 2 and sections 3.1 to 3.6 of chapter 3)	Equips students with advanced knowledge and skills in designing, analysing, and implementing error-correcting codes for reliable communication systems.

III (15 Hours)	The Golay code, Reed-Muller codes, Fast decoding of RM(1,m) , Cyclic linear codes. Generating and parity check matrices for cyclic codes. Finding cyclic codes. Dual cyclic codes (Sections 3.7 to 3.9 of Chapter .3 and Chapter 4 complete)	Studying these advanced topics in coding theory equips students with the knowledge, skills, and analytical abilities needed to design, analyze, and implement sophisticated coding schemes for reliable and efficient communication systems
IV (15 Hours)	BCH codes. Decoding 2-error-correcting BCH code. Reed-Solomon codes. Decoding (Chapter 5 complete and sections 6.1, 6.2 and 6.3 of chapter 6)	Studying BCH codes, decoding algorithms for BCH codes, Reed-Solomon codes, and related topics provides students with a strong foundation in advanced coding techniques and prepares them for careers in fields where error-correction coding is essential for ensuring reliable and efficient communication and storage of digital information.

References	**<u>Text Book:</u>** Coding Theory and Cryptography The Essentials (2nd edition) – D. R. Hankerson, D. G. Hoffman, D. A. Leonard, C. C. Lindner, K. T. Phelps, C. A. Rodger and J. R. Wall – Marcel Dekker (2000) **<u>Reference Books:</u>** 1.J. H. van Lint – Introduction to Coding Theory – Springer Verlag (1982) 2.E. R. Berlekamp – Algebraic Coding Theory – McGraw Hill (1968

Course Outcome	**After successful completion of this course, students will be able to:**
	1.By studying this course students will able ,to design, analyse, and implement error-correcting codes for reliable communication systems. They develop problem-solving skills, mathematical reasoning abilities, and a deep understanding of the principles underlying modern digital communication technology. 2. Will equip students with advanced knowledge and skills in designing, analysing, and implementing error-correcting codes for reliable communication systems. 3. Equips students with the knowledge, skills, and analytical abilities needed to design, analyse, and implement sophisticated coding schemes for reliable and efficient communication systems. 4.By studying BCH codes, decoding algorithms for BCH codes, Reed-Solomon codes, and related topics provides students with a strong foundation in advanced coding techniques and prepares them for careers in fields where error-correction coding is essential for ensuring reliable and efficient communication and storage of digital information.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE12 GRAPH THEORY

Course code & Title	**MSMAT04DSE12 GRAPH THEORY**
Course objectives	The course aims: Graph theory provides students with valuable analytical and problem-solving skills that are applicable across various disciplines and industries. It equips them with the tools to tackle complex problems and develop innovative solutions in their chosen fields of study or profession.

Module	**Content**	**Module Outcome**
I (15 Hours)	Basic results. Directed graphs. (Chapters I and II of the Text)	1.Able to Understand the fundamental concepts such as vertices, edges, and graphs. 2.Familiarity with different types of graphs, including simple graphs, multigraphs, pseudographs, and complete graphs 3.Get an idea about the adjacency matrices and adjacency lists for representing directed graphs. 4.Get an idea about the application of directed graphs in various real-world scenarios, such as network modelling, transportation systems, and social networks
II (15 Hours)	Connectivity. Trees (Chs. III and IV)	Studying these topics provides students with advanced knowledge and skills in graph theory, particularly focusing on the connectivity aspects and the rich structure and properties of trees.

III (15 Hours)	Independent sets and matchings. Eulerian and Hamiltonian graphs. (Chs. V and VI)	Studying these topics equips students with advanced knowledge and skills in graph theory, particularly focusing on independent sets, matchings, and the properties of Eulerian and Hamiltonian graphs. Understanding these concepts is essential for solving more complex problems in graph theory and applying graph theory techniques in various practical contexts
IV (15 Hours)	Graph colourings (Ch. VII)	1.Understanding the concept of a proper coloring, where adjacent vertices or edges are assigned different colors 2.Get an Exploration of basic results and theorems related to vertex coloring, such as Brooks' theorem, Vizing's theorem, and the four-color theorem.

References	**Text Book:** R. Balakrishnan, K. Ranganathan – A Text Book of Graph Theory –Springer (2000) **References:** 1.C. Berge – Graphs and Hypergraphs – North Holland (1973) 2.J. A. Bondy and V. S. R. Murty – Graph Theory with Applications, Mac Millan 1976 3.F. Harary – Graph Theory – Addison Wesley, Reading Mass. (1969) 4.K. R. Parthasarathy – Basic Graph Theory – Tata McGraw Hill (1994)

Course Outcome	**After successful completion of this course, students will be able to:**
	1.Studying this course provides students with a solid grounding in fundamental graph theory concepts and techniques, which are valuable in various fields including computer science, operations research, and network analysis 2. Studying this course provides students with a comprehensive understanding of connectivity and trees in graph theory, preparing them for further study or application in various fields such as computer science, operations research, and network analysis 3. Studying this course provides students with a comprehensive understanding of independent sets, matchings, Eulerian graphs, and Hamiltonian graphs in graph theory, preparing them for further study or application in various fields such as computer science, operations research, and network analysis. 4.Studying this course provides students with a comprehensive understanding of graph colorings in graph theory, preparing them for further study or application in various fields such as computer science, operations research, and network analysis.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.

Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE13 HARMONIC ANALYSIS

Course code & Title	**MSMAT04DSE13 HARMONIC ANALYSIS**
Course objectives	The course aims: Many Branches of Mathematics come together In Harmonic Analysis. Each adding richness to the subject and each giving insights Into the subject.. The course is a gentle introduction to Fourier Analysis and Harmonic Analysis.

Module	**Content**	**Module Outcome**
I (15 Hours)	Quick review of chapter 0, The Dirichlet Problem for a Disk, Continuous functions on the unit Disc, The method of Fourier, Uniform convergence, The formulas of Euler, Cesaro convergence, Fejer's theorem, At last the solution. Chapter 0 (sections 1 to 8) and 1)	This module aims to understand the Dirichlet problem and periodic functions
II (15 Hours)	Functions on (-pi, pi), Functions on other intervals, Functions with special properties, pointwise convergence of the Fourier series, Chapter 2	This module explores about the Fourier series and its convergences

III (15 Hours)	Normed vector spaces, Convergence in normed spaces, inner product spaces, infinite orthonormal sets, Hilbert spaces, the completion, wavelets. Chapter 3	This module recollects some of the important notions in functional analysis which is useful to study Fourier analysis
IV (15 Hours)	The Fourier transform on Z, Invertible elements in l^1(Z), The Fourier transform on R, Finite Fourier transform. Chapter 4 sections 1, 2, 3 and 6	This module introduces the concept of Fourier transforms.

References	<u>**TEXT BOOK:**</u> Carl L. DeVito, Harmonic Analysis, A gentle Introduction. <u>**REFERENCES**</u> **:** 1. Yitzhak Katznelson , An Introduction to Harmonic Analysis, 2. Geral B. Folland, acourse in abstract harmonic analysis 3. Anton Deitmar, A first course in harmonic analysis, Springer 4. Elias M. Stein and Guido Weiss, Introduction to Fourier analysis on Euclidean spaces 5. Edwin Hewitt; Kenneth A. Ross, Abstract Harmonic Analysis. Springer

Course Outcome	**After successful completion of this course, students will be able to:**
	1. Learn the Dirichlet problem, its solutions and uniqueness 2. Understand the Fourier series and its convergence 3. Learn about Fourier transforms

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE14 LIE ALGEBRA AND REPRESENTATION THEORY

Course code & Title	**MSMAT04DSE14 LIE ALGEBRA AND REPRESENTATION THEORY**
Course objectives	This course is mainly designed for a beginner to give a very basic algebraic introduction to the theory of Lie algebras and representation theory. Lie algebras have become essential to many parts of mathematics and theoretical physics. A good knowledge in Linear algebra and representation theory is sufficient to cover the first three modules of the textbook which is mainly intended in this course.

Module	Content	Module Outcome
I (15 Hours)	**The notion of Lie algebra-** Linear Lie algebras, Lie algebras of derivations Abstract Lie algebras, Ideals, Homomorphisms and representations, Automorphisms, Solvable and Nilpotent Lie algebras	Students can understand the notion of Lie algebra, Lie bracket operation, ideals in Lie algebra and its representations. This module introduces solvable and nilpotent Lie algebras and the understanding of Lie algebras via its ideals. An attempt to understand Engel's theorem is also executed.
II (15 Hours)	Semi simple Lie algebras, Theorems of Lie and Cartan, Lie's theorem Jordan - Chevalley decomposition, Cartan's criterion, Killing form, Criterion for semi simplicity, Simple ideals, Inner derivations, Abstract Jordan decomposition	Definition of semi simple Lie algebras, Lie and Cartan,s theorem are discussed. Cartan's criterion of solvability is discussed. The notions killing forms, inner derivations and simple idelas are discussed. Jordan decomposition of arbitrary semi simple Lie algebra is also discussed.

III (15 Hours)	Complete reducibility of representations, modules, Casimir element of a representation, Weyl,s theorem, Preservation of Jordan decomposition, Representations of sl(2,F), Weights and maximal vectors, classification of irreducible modules	Representations of the Lie algebra sl(2,F) is understood.
IV (15 Hours)	Root systems, Axiomatics, Reflections in a Euclidean space, Root systems, Examples, Pairs of roots, Simple roots and Weyl groups, Bases and Weyl chambers, Lemmas on simple roots, The Weyl group, Irreducible root systems, Classification, Cartan matrices, Coxeter graphs and Dynkin diagrams	Reflections in a Euclidean is understood. Main outcome of this module is the understanding of root systems in Euclidean spaces and its combinatorial descriptions.

References	**TEXT BOOK:** Introduction to Lie algebras and Representation theory - James E Humphreys **REFERENCES :** 1. Lie algebras of Finite and Affine Type - Roger Carter 2. Introduction to Lie algebras - Karin Erdmann and Mark J. Wildon 3. Reflection groups and Coxeter groups - James E Humphre

Course Outcome	**After successful completion of this course, students will be able to:**
	Students will understand the basics of Lie algebras and its representation theory. This course also helps in understanding the connection of Lie algebras with symmetries of polygons, a combinatorial description via reflections in Euclidean spaces.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE15 NUMBER THEORY

Course code & Title	MSMAT04DSE15 NUMBER THEORY
Course objectives	The course aims: The aim of the course is to give an introduction to basic concepts of elementary number theory in a combinatorial approach. Both multiplicative and additive problems are discussed.

Module	**Content**	**Module Outcome**
I (15 Hours)	Basic representation theorem. The fundamental theorem of arithmetic; combinatorial and computational number theory: Permutations and combinations, Fermat's little theorem, Wilson's theorem, Generating functions; Fundamentals of congruences- Residue systems, Riffling; Solving congruences- Linear congruences, Chinese remainder theorem, Polynomial congruences. Chapters 1-5	This module is intended to learn basic concepts and results in number theory including Fermat's little theorem, Wilson's theorem and Chinese remainder theorem.
II (15 Hours)	Arithmetic functions-combinatorial study of phi (n), Formulae for d (n) and sigma (n), multivariate arithmetic functions, Mobius inversion formula; Primitive roots- Properties of reduced residue systems, Primitive roots modulo p; Prime numbers-Elementary properties of Pi (x), Tchebychev's theorem. Chapters: 6 - 8	This module aim to understand Euler phi function, mobiles inversion formula and Tchebych ev's theorem.

III (15 Hours)	Quadratic congruences: Quadratic residues- Euler's criterion, Legendre symbol, Quadratic reciprocity law; Distribution of Quadratic residues- consecutive residues and nonresidues, Consecutive triples of quardratic residues. Chapters: 9 - 10	This module gives an idea of quadratic congruences, Legendre symbols and quadratic residues.
IV (15 Hours)	Additivity: Sums of squares- sums of two squares, Sums of four squares; Elementary partition theory- Graphical representation, Euler's partition theorem, Searching for partition identities; Partition generating functions- Infinite products as generating functions, Identities between infinite series and products. Chapters: 11 - 13	This module deals with the elementary partition theory, Euler's partition theorem and partition generation functions.

References	**<u>TEXT BOOK:</u>** George E Andrews: Number Theory, Dover Publications (1971) Chapter1 Section1.2, Chapters 2-13. **<u>REFERENCES</u> :** 1. Andre Weil-Basic Number Theory (3rd edn.) Springer-Verlag (1974). 2. Grosswald, E.-Introduction to Number Theory Brikhauser (2nd edition) 1984.

Course Outcome	After successful completion of this course, students will be able to:
	1. Get a basic idea of number theory and get familiar with its fundamental results 2. Understand the fundamentals of congruences and related results 3. Understand primitive roots and prime numbers 4. Learn about quadratic congruences and residues 5. Get comfortable with elementary partition theory

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE16 NUMERICAL ANALYSIS AND COMPUTING

Course code & Title	**MSMAT04DSE16 NUMERICAL ANALYSIS AND COMPUTING**
Course objectives	The course aims: The aim is to provide an introduction to the fundamental concepts of numerical analysis and computing.

Module	Content	Module Outcome
I (15 Hours)	**1 Principles of Numerical Calculations** 1.1 Common Ideas and Concepts, Fixed-Point Iteration, Newton's Method, Linearization and Extrapolation, Finite Difference Approximations, 1.2 Some Numerical Algorithms, Solving a Quadratic Equation, Recurrence Relations. Divide and Conquer Strategy. 1.3 Matrix Computations, Matrix Multiplication, Solving Linear Systems by LU Factorization, Sparse Matrices and Iterative Methods, Software for Matrix Computations. 1.4 The Linear Least Squares Problem, Basic Concepts in Probability and Statistics, Characterization of Least Squares Solutions, The Singular Value Decomposition, The Numerical Rank of a Matrix 1.5 Numerical Solution of Differential Equations, Euler's Method , Introductory Example, Second Order Accurate Methods	1. Students will gain a solid understanding of fundamental concepts and techniques in numerical analysis, including fixed-point iteration, Newton's method, linearization, extrapolation, and finite difference approximations. 2. Students will become familiar with specific numerical algorithms for solving common mathematical problems, such as quadratic equations, recurrence relations, and problems that can be solved using the divide and conquer strategy 3. Students will learn about important topics in matrix computations, including matrix multiplication, solving linear systems using LU factorization, handling sparse matrices, and iterative methods for solving linear systems.

II (15 Hours)	**2. How to Obtain and Estimate Accuracy** 2.1 Basic Concepts in Error Estimation, Sources of Error, Absolute and Relative Errors, Rounding and Chopping. 2.2 Computer Number Systems, The Position System, Fixed- and Floating-Point Representation, IEEE Floating-Point Standard.,Elementary Functions, Multiple Precision 2.3 Accuracy and Rounding Errors, Floating-Point Arithmetic, Basic Rounding Error Results, Statistical Models for Rounding Errors, Avoiding Overflow and Cancellation.	1.Students will grasp fundamental concepts related to error estimation in numerical computations, including sources of error, absolute and relative errors, and rounding and chopping. 2. Students will learn about accuracy and rounding errors in numerical computations, particularly in floating-point arithmetic 3.Students will learn how to accurately compute functions such as trigonometric, exponential, and logarithmic functions, which are commonly encountered in scientific and engineering computations.

III (15 Hours)	**3. Interpolation and Approximation** 3.1 The Interpolation Problem, Bases for Polynomial Interpolation, Conditioning of Polynomial 3.2 Interpolation Formulas and Algorithms, Newton's Interpolation ,Inverse Interpolation, Barycentric Lagrange Interpolation, Iterative Linear Interpolation, Fast Algorithms for Vandermonde Systems, The Runge Phenomenon 3.3 Generalizations and Applications, Hermite Interpolation, Complex Analysis in Polynomial Interpolation, Rational Interpolation, Multidimensional Interpolation. 3.4 Piecewise Polynomial Interpolation, Bernštein Polynomials and Bézier Curves, Spline Functions, The B-Spline Basis, Least Squares Splines Approximation. The Fast Fourier Transform. The FFT Algorithm.	1.Students will learn advanced interpolation techniques such as Barycentric Lagrange interpolation, iterative linear interpolation, and fast algorithms for Vandermonde systems. 2. Students will delve into piecewise polynomial interpolation techniques, including Bernstein polynomials, Bézier curves, spline functions, and the B-spline basis 3. Students will gain knowledge of the Fast Fourier Transform (FFT) algorithm, a fast computational technique for efficiently computing the Discrete Fourier Transform (DFT)

IV (15 Hours)	**4. Numerical Integration** 4.1 Interpolatory Quadrature Rules ,Treating Singularities, Classical Formulas, Super-convergence of the Trapezoidal Rule, Higher-Order Newton–Cotes' Formulas 4.2 Integration by Extrapolation , The Euler–Maclaurin Formula, Romberg's Method, Oscillating Integrands Adaptive Quadrature	1. Students will learn about interpolatory quadrature rules for approximating definite integrals. 2. They will understand the importance of numerical stability and accuracy when dealing with challenging integrands encountered in scientific computations. 3.Students will understand advanced techniques for improving the accuracy of numerical integration, including integration by extrapolation methods such as the Euler–Maclaurin formula and Romberg's method.

References	<u>**Text Books**</u>: 1.Numerical Analysis in Scientific Computing (Vol.1) Germund Dahlquist, Cambridge University press) 2.Numerical Recipes in C – The art of scientific computing (3rd edn.)(2007) – William Press (also available on internet) <u>**Reference Books**</u>: 1.Applied Numerical Analysis using MATLAB. (2nd Edn) Laurene Fausett (Pearson) 2. Numerical Analysis: Mathematics of Scientific Computing, David Kincaid, Chency et.al. , Cengage Learning (Pub), 3rd Edn 3. Deuflhard P. & A. Hofmann – Numerical Analysis in Modern Scientific Computing – Springer (2002).

Course Outcome	After successful completion of this course, students will be able to:
	1.studying this course will equip students with a strong foundation in numerical analysis, enabling them to understand and apply numerical methods to solve a wide range of mathematical problems encountered in scientific computing and related fields. 2.Studying this course will equip students with a solid understanding of error estimation, computer number systems, accuracy, and rounding errors in numerical computations 3.Studying this course will get a good knowledge in advanced topics in interpolation and approximation will empower students with a deeper understanding of numerical techniques for data analysis, curve fitting, and signal processing. 4.Studying this course will equip students with a deeper understanding of numerical techniques for approximating integrals, handling challenging integrands, and improving the accuracy of numerical computations.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks

End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE17 Operator Algebras

Course code & Title	MSMAT04DSE17 Operator Algebras
Course objectives	The course aims: The objective of this course is to introduce fundamental topics in operator theory. It is a field that has great importance for other areas of mathematics and physics, such as algebraic topology, differential geometry, quantum mechanics. We discuss the basics results of Banach algebras and C* algebras.

Module	Content	Module Outcome
I (15 Hours)	Review on Functional analysis , Banach algebras and the invertible group, The spectrum, Multiplicative linear functional, (Sections 1 to 4)	1. Students will understand the concepts of functional analysis, including Banach spaces and Banach algebras. 2. Students will be able to analyze invertible groups within Banach algebras and comprehend their significance. 3. Students will grasp the notion of spectrum and multiplicative linear functionals, along with their applications in functional analysis.

II (15 Hours)	The Gelfand Transform and applications, Examples of maximal ideal spaces, Non-unital Banach algebras, (Sections 5 to 7)	1.Students will master the Gelfand transform and its applications in the study of Banach algebras. 2. Students will explore examples of maximal ideal spaces and understand their role in the structure theory of Banach algebras. 3.Students will be able to analyze non-unital Banach algebras and comprehend their properties and significance in functional analysis
III (15 Hours)	C* algebras, Commutative C* algebras, the spectral theorem (upto 10.3), Polar Decomposition (Sections 8 , 9, 10, 12)	1. Students will gain a comprehensive understanding of C* algebras, including their definition, properties, and applications. 2. Students will explore commutative C* algebras and understand the spectral theorem and its applications in functional analysis. 3. Students will be able to apply the polar decomposition theorem and analyze its implications in the context of C* algebras.

IV (15 Hours)	Positive linear functional and states, The GNS construction, Non-unital C* algebras, Strong and weak – operator topologies(Sections 13,14,15 , 16)	1. Students will comprehend the concept of positive linear functionals and states in the context of C* algebras. 2.Students will master the GNS construction and understand its role in constructing representations of C* algebras. 3. Students will analyze non-unital C* algebras and explore the strong and weak-operator topologies, gaining insight into their properties and applications.

References	<u>**TEXT BOOK:**</u> Kehe Zhu, An introduction to operator algebras CRC Press 1993. <u>**Reference Books:**</u> 1. Introduction to topology and modern analysis, McGraw Hill Education ,2017 2. R V Kadison and JR. Ringrose: Fundamentals of the theory of Operator algebras , volume 1 , II Academic press, 1983. 3. W. Arveson, An invitation to C* algebras , springer 1998. 4. W. Rudin, Functional analysis, McGraw Hill Education . 5. V S Sunder, An invitation to von Newmann algebras , springer 1998

Course Outcome	**After successful completion of this course, students will be able to:**
	1. Students will demonstrate a thorough understanding of fundamental concepts in functional analysis and operator algebras. 2. Students will develop proficiency in analyzing and applying advanced topics such as the Gelfand transform, maximal ideal spaces, and the spectral theorem. 3. Students will gain the ability to analyze and interpret various types of algebras, including Banach algebras and C* algebras, and their applications in mathematical analysis and quantum mechanics. 4.Students will be equipped with the necessary skills to solve problems and conduct research in the field of operator algebras and functional analysis

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8

MSMAT04DSE18 REPRESENTATION THEORY OF FINITE GROUPS

Course code & Title	**MSMAT04DSE18 REPRESENTATION THEORY OF FINITE GROUPS**
Course objectives	The aim of this course is to give an introduction to representation theory . Representation theory is an area of mathematics which studies symmetry in linear spaces. The theory , roughly speaking, is a fundamental tool for studying symmetry by means of linear algebra.

Module	**Content**	**Module Outcome**
I (15 Hours)	Introduction, G- modules, Characters, Reducibility, Permutation Representations, Complete reducibility, Schur's lemma, The commutant (endomorphism) algebra. (Sections: 1.1 to 1.8)	It introduces the definition of representations of a finite group and there by introduces the notion of group modules. Some basics theorems are also discussed.
II (15 Hours)	Orthogonality relations, the group algebra, the character table, finite abelian groups, the lifting process, linear characters. (section: 2.1 to 2.6)	This chapter introduces the crucial notion of orthogonality relations between representations, character table. Also representation theory of finite abelian group is more specifically understood.
III (15 Hours)	Induced representations, reciprocity law, the alternating group A_5, Normal subgroups, Transitive groups, the symmetric group, induced characters of S_n. (Sections: 3.1 to 3.4 & 4.1 to 4.3)	It introduces the concepts of induced and discusses the Frobenius law of reciprocity which relates inner products of restricted and induced characters.

References	**TEXT BOOK:** Walter Ledermann, Introduction to Group Characters, Cambridge university press 1087. (Second Edition) **REFERENCES :** [1] C. W. Kurtis and I. Reiner, Representation Theory of Finite Groups and Associative Algebras. American Mathematical society 2006. Algebras, John Wiley & Sons, New York(1962) 2) W **Fulton**, J. **Harris ,Representation Theory, A first course. Springer 2004.** [2] Fulton, The Representation Theory of Finite Groups, Lecture Notes in Mathematics, No. 682, Springer 1978. [3] C. Musli, Reprsentations of Finite Groups, Hindustan Book Agency, New Delhi (1993) [5] J.P. Serre, Linear Reprsentation of Finite Groups, Graduate Text in Mathematics, Vol 42, Springer (1977). [6]Bruce E Sagan, The symmetric group – Representations, combinatorial algorithms and symmetric functions.

Course Outcome	After successful completion of this course, students will be able to:
	The course helps in gaining a basic introduction the linear representation theory of finite groups. The basic concepts of characters, orthogonality relations of characters, induced representations and Frobenius reciprocity law is discussed. A brief introduction to the representation theory of symmetric group S_n and its characters can further hep the student to do advanced courses in combinatorics.

Teaching Learning Strategies	Direct Instruction: Brainstorming lectures, Problem-solving sessions, Explicit Teaching, E-learning(Video), Interactive Instruction: Active cooperative learning, Seminars, Assignments, Library work and Group discussion and Presentation by individual student/ Group representatives.
Mode of Transaction	Face to face: Lecture method Learner-centered technique: Computer-assisted learning & Individual project teaching, Seminar, Viva-voce

ASSESSMENT RUBRICS

Components	Marks
End Semester Evaluation	60
Continuous Evaluation	40
Test papers	16
Seminar presentations/Discussions/Debate, etc.	16
Assignment	8