Post Graduate Curriculum Framework

With effect from the Academic Session 2026–27, the M.A./M.Sc. in (Mathematics) programme in the Universities of Bihar shall be offered in accordance with the UGC Curriculum and Credit Framework for Postgraduate Programmes (PGCF) and the provisions of the National Education Policy (NEP), 2020.

The programme provides flexibility to students to pursue either a Two-Year Master's Degree Programme or a One-Year Master's Degree Programme for candidates who have completed a four-year undergraduate degree with the requisite credits and qualifications as prescribed by UGC.

The curriculum is designed under the Choice Based Credit System (CBCS) and comprises a combination of Core Courses (CCs), Discipline Specific Electives (DSEs), Generic Electives (GEs), Skill Enhancement Courses (SECs), Ability Enhancement Courses (AECs), and Value Added Courses (VACs). The programme seeks to impart advanced theoretical knowledge, computational proficiency, research aptitude, and practical skills in Statistics and its applications.

Each academic year shall consist of two semesters. Students shall be required to successfully complete the prescribed combination of Core, Elective (Discipline/Generic/Open), Skill Enhancement, Ability Enhancement, and Value Added Courses in each semester to fulfil the credit requirements of the programme.

The curriculum incorporates contemporary developments in (Mathematics), including (relevant topics of your programme). The syllabus and reading materials shall be reviewed periodically to ensure alignment with emerging developments in academia, research, industry, and public policy.

Teaching-learning methodologies may inciude lectures, tutorials, seminars, laboratory sessions, statistical computing exercises, case studies, project work, field-based applications, and research assignments. Practical training shall provide hands-on experience in the use of statistical software packages, data analysis techniques, computational tools, and real-world problem-solving.

Assessment shall be conducted through a combination of continuous evaluation and end-semester examinations, including assignments, presentations, practical examinations, projects, viva-voce examinations, and written tests, as prescribed by the authorities concerned from time to time.

Students shall have the opportunity to choose elective and generic courses in accordance with their academic interests, subject to the availability of courses and institutional regulations, thereby promoting interdisciplinary learning and specialization within the broad domain of Mathematics.

24/07/26

Kalpana Srivastava
Officer on special duty (Judicial)

15/06/26

15/6/26

COURSE OF STUDIES
M.A. / M.Sc. MATHEMATICS

MATHEMATICS / M.A. / M.Sc.	
Programme Level	Master of Arts (M.A.) / Master of Science (M.Sc.)
Subject / Discipline	Mathematics
Faculty	Faculty of Arts / Science
University	Universities of Bihar established under the BSU Act, 1976 / PU Act, 1976
Duration	Two Years / Four Semesters
NHEQF Level	Level 6.5
Effective from	2026-27 onwards

A PART A - PROGRAMME OVERVIEW & OBJECTIVES

A.1 Graduate Attributes (GAs)

The M.Sc. Mathematics programme is designed to develop the following graduate attributes in alignment with the National Higher Education Qualifications Framework (NHEQF) Level 6.5:

Graduate Attribute	Description
Knowledge and Understanding	Advanced understanding of pure and applied mathematics, including algebraic, analytical, computational and modelling perspectives.
Technical and Professional Skills	Ability to use mathematical software, computational tools, symbolic computation, numerical methods and scientific writing tools.
Application of Knowledge and Skill	Capacity to apply mathematical theories and techniques to solve abstract and real-world problems.
Generic Learning Outcomes	Logical reasoning, problem-solving, proof-writing, abstraction, interpretation and communication.
Constitutional, Ethical and Moral Values	Academic honesty, responsible research practice, proper citation, integrity and respect for intellectual contribution.
Employability and Job-Ready Skills	Readiness for teaching, research, competitive examinations, data-based professions, computational work and interdisciplinary careers.
Entrepreneurial and Innovation Mindset	Ability to model problems, build analytical tools, use software, develop projects and pursue independent academic or professional initiatives.

A.2 Programme Outcomes (POs)

The Programme Educational Objectives describe the career and professional accomplishments that graduates are expected to attain within three to five years of graduation.

PO Code	Programme Outcome
PO1	Demonstrate advanced knowledge of core and emerging areas of pure and applied mathematics.
PO2	Analyze and solve complex mathematical problems using rigorous logical reasoning.
PO3	Apply analytical, algebraic, computational and numerical methods in mathematical problem-solving.
PO4	Evaluate mathematical arguments, proofs, models and computational results with precision.
PO5	Design mathematical models for problems arising in science, engineering, economics, technology and allied disciplines.
PO6	Create well-structured mathematical documents, reports and presentations using appropriate scientific writing tools.
PO7	Communicate mathematical ideas effectively through written, oral and digital modes.
PO8	Engage in lifelong learning and adapt to new developments in mathematics, software and interdisciplinary applications.
PO9	Use mathematical software and programming tools for computation, visualization, modelling and experimentation.
PO10	Apply ethical principles in academic writing, research, citation, publication and professional practice.

A.3 Programme Specific Outcomes (PSOs)

After successful completion of the M.Sc. Mathematics programme, a student shall demonstrate the following learning outcomes:

PSO Code	Programme Specific Outcome
PSO1	Apply advanced concepts of discrete mathematics, algebra, analysis, linear algebra, differential equations, integral equations, graph theory and computational mathematics.
PSO2	Assess mathematical structures and models using abstract, analytical and computational techniques.
PSO3	Interpret mathematical theories and results in relation to research problems, applications and interdisciplinary contexts.
PSO4	Implement mathematical algorithms using MATLAB and Mathematica.
PSO5	Conduct mathematical literature review, seminar presentation, project work and dissertation-oriented writing.
PSO6	Apply mathematical methods in competitive examinations, teaching, research and professional analytical roles.

KD 24/07/26

Vinayak Kumar 15/06/26

Vipul Sneh 15/6/26

B PART B - COURSE STRUCTURE (CBCS/NHEQF FRAMEWORK)

B.1 Semester-wise Course Structure

The following table presents the full four-semester course structure. Column headings: L = **Lectures per week**; T = Tutorials per week; P = Practicals per week; CC = Core Course; DSE = Discipline Specific Elective; GE/OE = Generic/Open Elective; SEC = Skill Enhancement Course; PROJ = Project/Dissertation.

S.No.	Paper Code	Title of the Course/Paper	L	T	P	Credits	Max. Marks	Type
SEMESTER I								
1	MSMAT-CC 101	Core Course I: Discrete Mathematics	3	1	0	4	100	CC
2	MSMAT-CC 102	Core Course II: Advanced Algebra	3	1	0	4	100	CC
3	MSMAT-CC 103	Core Course III: Advanced Differential Equations	3	1	0	4	100	CC
4	MSMAT-CC 104	Core Course IV: Research Methodology and Scientific Writing	3	1	0	4	100	CC
5	MSMAT-GE 105/ GE 106	Generic Elective I: Number Theory/ Mathematical Finance	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester I	17	5	**0**	**22**	**600**	
SEMESTER II								
1	MSMAT-CC 201	Core Course I: Linear Algebra	3	1	0	4	100	CC
2	MSMAT-CC 202	Core Course II: Advanced Real Analysis	3	1	0	4	100	CC
3	MSMAT-CC 203	Core Course III: Integral Equations	3	1	0	4	100	CC
4	MSMAT-CC 204	Core Course IV: Mathematical Software	0	0	4	4	100	CC
5	MSMAT-GE 205/ GE 206	Generic Elective I: Graph Theory / Fuzzy Theory	3	1	0	4	100	GE
6		VAC/AEC/SEC	2	0	0	2	100	VAC/AEC/SEC
		Total — Semester II	**17**	**5**	**0**	**22**	**600**	

Particulars	Semester	Course Code	Course Title
Basket I	I	MSMAT-GE 105	Number Theory
		MSMAT-GE 106	Mathematical Finance
Basket II	II	MSMAT-GE 205	Graph Theory
		MSMAT-GE 206	Fuzzy Theory

C PART C — COURSES OF STUDIES

Instructions to Course Experts: Replicate Part C in full for each paper listed in the Course Structure above. Complete all fields; do not leave sections blank. Use 'Not Applicable' where a field genuinely does not apply.

C-1 MSMAT-CC 101 Discrete Mathematics

C-1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 101
Title of the Paper	Core Course I: Discrete Mathematics
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester I
Nature of Course	Core Course (CC)
L – T – P	3 – 1 – 0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C-2 Marks Distribution

Component	Paper I	Practical	IA	Total (ESE+IA/ESE+PRA)
End Semester Examination	70	—	—	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	—	—	30	30
Maximum Marks	70	—	30	100
Passing Marks	32	—	13	45 (45%)

Note: Internal Assessment shall be conducted on the basis of attendance, class tests, seminars, assignments, and viva voce as provided in the regulation.

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Vijnath Kumar 15/06/26

Vishal Singh 15/6/26

Kaushal 15/6/26

C-3 Course Objectives (COBs)

COB No.	Course Objectives
COB 1	To develop advanced understanding of discrete mathematical structures.
COB 2	To introduce combinatorial methods and recurrence-based reasoning.
COB 3	To connect Boolean algebra and logic with algebraic and computational applications.
COB 4	To prepare students for graph theory, algorithms, cryptography and finite structures.
COB 5	To strengthen proof-writing and problem-solving in finite and countable settings.

C-4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain advanced concepts of sets, relations, functions and ordered structures.
CLO 2	Demonstrate combinatorial counting methods and recurrence-solving techniques.
CLO 3	Analyze Boolean algebra, lattices and partially ordered structures.
CLO 4	Evaluate graph-theoretic structures and their mathematical properties.
CLO 5	Develop discrete mathematical models for computational and applied problems.

C-5Syllabus - Unit-wise Breakdown

Course Name: **DISCRETE MATHEMATICS (MSMAT-CC101)**		
Unit	**Content**	**Suggested Lecture Hours**
I	Equivalence relations and partitions; partial orders; Hasse diagrams; chains and antichains; maximal and minimal elements; greatest and least elements; lattices; complete lattices; distributive and complemented lattices; direct sum and homomorphisms of lattices.	12
II	Principle of inclusion and exclusion; generalized pigeonhole principle; permutations and combinations with restrictions; ordinary and exponential generating functions; recurrence relations; linear recurrence relations with constant coefficients.	10
III	Propositional logic; logical equivalence; tautologies and contradictions; normal forms; predicate logic: introduction; rules of inference; mathematical induction and strong induction; recursive definitions; Boolean algebras; Boolean functions; normal forms; Boolean rings and Karnaugh maps; algebraic representation of logical structures.	14
IV	Definition of Graphs; paths, circuits and subgraphs; induced subgraphs, degree of a vertex, connectivity, planar graphs and their properties. Trees and simple applications of graphs.	12
V	Finite-state machines; automata: elementary introduction; discrete probability models; recurrence models in computer science and population problems.	12
	Total Suggested Lectures	**60** (For 4 Credit Course)

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C- 6 Prescribed Textbooks

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw-Hill.
2. C. L. Liu and D. P. Mohapatra, Elements of Discrete Mathematics, McGraw-Hill.
3. R. P. Grimaldi, Discrete and Combinatorial Mathematics, Pearson.
4. J. P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill.

C-7 Reference Books & Readings

1. N. Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall.
2. R. A. Brualdi, Introductory Combinatorics, Pearson.
3. J. H. van Lint and R. M. Wilson, A Course in Combinatorics, Cambridge University Press.
4. Douglas B. West, Introduction to Graph Theory, Pearson.

C-7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

C.1 MSMAT-CC 102: Advanced Algebra

C-1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 102
Title of the Paper	Advanced Algebra
Programme / Subject	M.A./ MSc. Mathematics
Semester	Semester I
Nature of Course	Core Course (CC)
L - T – P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C-2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	—	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

C-3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To develop advanced structural understanding of groups and rings.
COB 2	To introduce group actions, solvable groups and nilpotent groups.
COB 3	To study composition series and Noetherian rings.
COB 4	To introduce module theory and exact sequences.
COB 5	To connect module theory with canonical forms and finitely generated abelian groups.

C-4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain group actions and their applications to finite group structure.
CLO 2	Demonstrate advanced knowledge of solvable, nilpotent and composition series.
CLO 3	Analyze Euclidean domains, PIDs, UFDs and Noetherian rings.
CLO 4	Evaluate modules, submodules, quotient modules and homomorphisms.
CLO 5	Develop algebraic decompositions using structure theorems for modules over PIDs.

C-5 Syllabus - Unit-wise Breakdown

Course Name: ADVANCED ALGEBRA (MSMAT-CC102)

Unit	Content	Suggested Lecture Hours
I	Group and their properties; Permutation groups;Group actions; orbit-stabilizer theorem; class equation; conjugacy action; group action on cosets; permutation representations; applications to finite groups; Sylow theorems with applications; simplicity and non-simplicity tests.	10
II	Normal series; subnormal series; composition series; Jordan-Holder theorem; derived series; solvable groups; nilpotent groups; lower and upper central series; finite p-groups; relation between nilpotent and solvable groups; simple groups.	12
III	Prime ideals and maximal ideals; nilpotent elements and nilradical; Jacobson radical; Euclidean domains; principal ideal domains; unique factorization domains; irreducible and prime elements; relation among ED, PID and UFD; Noetherian rings; Field and extension field.	12
IV	Modules; submodules; quotient modules; module homomorphisms; kernel and image; exact sequences; direct sums and direct products; free modules; cyclic modules; finitely generated modules; simple and semisimple modules: introductory examples.	14
V	Torsion elements and torsion submodules; annihilators; cyclic decomposition; structure theorem for finitely generated modules over a PID; invariant factor form; elementary divisor form; applications to finitely generated abelian groups.	12
	Total Suggested Lectures	**60** (For 4 Credit Course)

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Officer on special duty (Judicial)

C-6 Prescribed Textbooks / Essential Readings

1. D. S. Dummit and R. M. Foote, Abstract Algebra, Wiley.
2. I. N. Herstein, Topics in Algebra, Wiley.
3. Michael Artin, Algebra, Pearson.
4. Thomas W. Hungerford, Algebra, Springer.

C-7 Reference Books & Suggested Readings

1. Serge Lang, Algebra, Springer.
2. N. Jacobson, Basic Algebra I, Dover.
3. Joseph J. Rotman, Advanced Modern Algebra, American Mathematical Society.
4. Atiyah and Macdonald, Introduction to Commutative Algebra, Addison-Wesley.

C-7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

C-1 MSMAT-CC 103: Advanced Differential Equations

C-1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 103
Title of the Paper	Advanced Differential Equations
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester I
Nature of Course	Core Course (CC)
L - T – P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C-2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

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Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

C-3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To develop rigorous theory of existence and uniqueness for differential equations.
COB 2	To introduce qualitative theory of systems of differential equations.
COB 3	To study stability, phase plane and linearization methods.
COB 4	To introduce Sturm-Liouville theory and eigenfunction expansions.
COB 5	To prepare students for PDE, integral equations, dynamical systems and mathematical modelling.

C-4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain existence and uniqueness theorems for ordinary differential equations.
CLO 2	Demonstrate methods for analysing linear and nonlinear systems of differential equations.
CLO 3	Analyze phase plane, stability and linearization of dynamical systems.
CLO 4	Evaluate Sturm-Liouville problems and eigenfunction expansions.
CLO 5	Develop mathematical models using advanced differential equation methods.

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Vijay Kumar 15/06/26

Vikul Sodhi 15/6/26

15/6/26

Course Name: ADVANCED DIFFERENTIAL EQUATIONS (MSMAT-CC 103)

Unit	Content	Suggested Lecture Hours
I	Initial value problems; Lipschitz condition; successive approximations; Picard-Lindelof theorem; Peano existence theorem: statement; continuation of solutions; dependence on initial conditions and parameters; maximal interval of existence; Gronwall inequality and applications; examples of non-uniqueness.	12
II	Systems of first-order differential equations; fundamental matrix; Wronskian for systems; matrix exponential; homogeneous and non-homogeneous linear systems; variation of constants formula; systems with constant coefficients; eigenvalue method.	12
III	Autonomous systems; phase plane analysis; critical points; stability of linear systems; nonlinear systems and linearization; Lyapunov stability: introduction; Lyapunov functions: elementary examples.	12
IV	Two-point boundary value problems; self-adjoint differential operators; Green's functions for boundary value problems; construction of Green's function in simple cases; non-homogeneous boundary value problems; existence of solutions.	12
V	Regular Sturm-Liouville problems; eigenvalues and eigenfunctions; orthogonality of eigenfunctions; expansion in eigenfunctions; Rayleigh quotient: introduction; singular Sturm-Liouville problems: idea; applications to heat, wave and Laplace equations.	12
	Total Suggested Lectures	**60** (For 4 Credit Course)

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C-6 Prescribed Textbooks / Essential Readings

1. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw-Hill.
2. G. F. Simmons, Differential Equations with Applications and Historical Notes, McGraw-Hill.
3. M. Braun, Differential Equations and Their Applications, Springer.
4. Lawrence Perko, Differential Equations and Dynamical Systems, Springer.

C-7 Reference Books & Suggested Readings

1. V. I. Arnold, Ordinary Differential Equations, Springer.
2. Hirsch, Smale and Devaney, Differential Equations, Dynamical Systems, and an Introduction to Chaos, Academic Press.
3. Boyce and DiPrima, Elementary Differential Equations and Boundary Value Problems, Wiley.
4. Walter A. Strauss, Partial Differential Equations: An Introduction, Wiley.

C-7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

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Officer on special duty (Judicial)

C-1 MSMAT-CC 104: Research Methodology and Scientific Writing

C-1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 104
Title of the Paper	Research Methodology and Scientific Writing
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester I
Nature of Course	Core Course (CC)
L - T - P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	—	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

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Karpana Srivastava
Officer on special duty (Judicial)

Vinay Kumar 15/06/26

Vikash Singh 15/6/26

15/6/26

C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To introduce the nature and methods of mathematical research.
COB 2	To train students in literature review, citation and academic referencing.
COB 3	To develop mathematical writing and dissertation preparation skills.
COB 4	To introduce LaTeX as a tool for mathematical documentation.
COB 5	To promote academic integrity, publication ethics and seminar presentation skills.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the nature of mathematical research and formulate research problems.
CLO 2	Demonstrate literature review skills using standard mathematical databases.
CLO 3	Analyze mathematical papers, monographs and research reports critically.
CLO 4	Evaluate ethical issues in academic writing, citation and publication.
CLO 5	Develop dissertation proposals, seminar reports and mathematical documents in LaTeX.

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Vijnath Kumar 15/06/26

Vikash Singh 15/6/26

15/6/26

C.5 Syllabus - Unit-wise Breakdown

Course Name: RESEARCH METHODOLOGY AND SCIENTIFIC WRITING (MSMAT-CC 104)		
Unit	**Content**	**Suggested Lecture Hours**
I	Meaning of research in mathematics; pure, applied and computational research; mathematical problems, conjectures and theorems; proof as method; examples and counterexamples; abstraction and generalization; formulation of research questions; objectives and methodology; structure of a research proposal; distinction between exposition, survey, review and original research.	12
II	Sources of mathematical literature; textbooks, monographs, research papers, conference proceedings and preprints; university libraries; MathSciNet, zbMATH, arXiv, Google Scholar, DOAJ and institutional repositories; reading a mathematical paper; preparing summaries, notes and annotated bibliographies; identifying research gaps.	12
III	Principles of mathematical writing; definitions, examples, theorems, lemmas, propositions, corollaries, remarks and proofs; writing clear proofs; introduction to LaTeX; document classes; mathematical symbols; equation environments; matrices; theorem environments; tables and figures; cross-referencing; BibTeX and bibliography management; preparation of assignments, seminar reports and dissertation chapters.	12
IV	Academic integrity; plagiarism and self-plagiarism; paraphrasing and acknowledgement; citation ethics; authorship and contributorship; peer review process; preprints and journals; predatory journals and conferences; copyright and open access; intellectual property rights; ethical use of artificial intelligence and digital tools.	12
V	Selection of dissertation topic; preparation of abstract and keywords; structure of dissertation; chapter planning; review of literature; statement of problem; methodology; results and discussion; conclusion and future scope; seminar presentation; use of slides and blackboard; responding to questions; viva voce; evaluation of clarity, originality, references and mathematical correctness.	12
	Total Suggested Lectures	**60** (For 4 Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. Nicholas J. Higham, Handbook of Writing for the Mathematical Sciences, SIAM.
2. Steven G. Krantz, A Primer of Mathematical Writing, American Mathematical Society.
3. George Gratzer, More Math Into LaTeX, Springer.
4. Leslie Lamport, LaTeX: A Document Preparation System, Addison-Wesley.

C.7 Reference Books & Suggested Readings

1. George Polya, How to Solve It, Princeton University Press.
2. Kevin P. Lee, A Guide to Writing Mathematics, Mathematical Association of America.
3. Robert A. Day and Barbara Gastel, How to Write and Publish a Scientific Paper, Cambridge University Press.
4. C. R. Kothari and Gaurav Garg, Research Methodology: Methods and Techniques, New Age International.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

C.1 MSMAT-GE 101A: Number Theory

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-GE 101A
Title of the Paper	Number Theory
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester I
Nature of Course	Generic/Open Elective (GE/OE) - Option A
L - T - P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To develop advanced understanding of divisibility, congruences and arithmetic functions.
COB 2	To introduce Diophantine equations and continued fractions.
COB 3	To study primitive roots and quadratic residues.
COB 4	To connect classical number theory with cryptographic applications.
COB 5	To strengthen proof and computational techniques in elementary number theory.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain divisibility, congruences and arithmetic functions.
CLO 2	Demonstrate techniques for solving Diophantine equations.
CLO 3	Analyze primitive roots and quadratic residues.
CLO 4	Evaluate classical theorems in elementary number theory.
CLO 5	Develop elementary number-theoretic applications in cryptography.

24/07/26
Kalpana Srivastava
Officer on special duty (Judicial)

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C.5 Syllabus - Unit-wise Breakdown

Course Name: NUMBER THEORY (MSMAT-GE 101A)		
Unit	**Content**	**Suggested Lecture Hours**
I	Divisibility; Euclidean algorithm; greatest common divisor; congruences; residue classes; complete and reduced residue systems; Fermat theorem; Euler theorem; Wilson theorem; Chinese remainder theorem and applications.	15
II	Arithmetic functions; divisor function; sum of divisors function; Euler phi function; Mobius function; Mobius inversion formula; multiplicative functions; convolution of arithmetic functions; applications to counting problems.	15
III	Linear Diophantine equations; Pythagorean triples; quadratic Diophantine equations: selected examples; Pell equation: introduction; representation of integers as sums of squares: elementary discussion; continued fractions and rational approximations: introduction.	10
IV	Order of an integer modulo n; primitive roots; existence of primitive roots: selected cases; quadratic residues; Legendre symbol; Euler criterion; Gauss lemma; law of quadratic reciprocity: statement and applications.	12
V	Classical cryptography: types and examples; public-key cryptography: elementary idea; RSA cryptosystem.	08
	Total Suggested Lectures	**60** (For 4 Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. David M. Burton, Elementary Number Theory, McGraw-Hill.
2. Ivan Niven, Herbert S. Zuckerman and Hugh L. Montgomery, An Introduction to the Theory of Numbers, Wiley.
3. G. H. Hardy and E. M. Wright, An Introduction to the Theory of Numbers, Oxford University Press.
4. Kenneth H. Rosen, Elementary Number Theory and Its Applications, Pearson.

C.7 Reference Books & Suggested Readings

1. Tom M. Apostol, Introduction to Analytic Number Theory, Springer.
2. Neal Koblitz, A Course in Number Theory and Cryptography, Springer.
3. W. J. LeVeque, Fundamentals of Number Theory, Dover.
4. Ireland and Rosen, A Classical Introduction to Modern Number Theory, Springer.

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C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

C.1 MSMAT-GE 101B: Mathematical Finance

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-GE 101B
Title of the Paper	Mathematical Finance
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester I
Nature of Course	Generic/Open Elective (GE/OE) - Option B
L - T - P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

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Vishal Gnada 15/6/26

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C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To introduce interest theory, annuities and fundamental financial mathematics.
COB 2	To develop bond valuation and yield calculation techniques.
COB 3	To introduce risk-return analysis and portfolio models.
COB 4	To study elementary derivative instruments and option pricing models.
COB 5	To develop mathematical models for financial decision-making.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain interest rates, annuities and basic financial mathematics.
CLO 2	Demonstrate bond valuation and yield calculations.
CLO 3	Analyze portfolio risk and return.
CLO 4	Evaluate derivative instruments using elementary models.
CLO 5	Develop mathematical models for financial decision-making.

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C.5 Syllabus - Unit-wise Breakdown

Course Name: MATHEMATICAL FINANCE (MSMAT-GE 101B)		
Unit	**Content**	**Suggested Lecture Hours**
I	Simple and compound interest; effective and nominal rates; force of interest; present value and accumulated value; equations of value; annuities immediate and due; perpetuities; amortization schedules; sinking funds.	15
II	Bond valuation; price-yield relationship; duration and convexity; term structure of interest rates; immunization: elementary idea; fixed income securities; risk associated with bonds.	08
III	Return and risk; expected return; variance and covariance; diversification; two-asset and multi-asset portfolios; Markowitz mean-variance model; efficient frontier: introductory treatment; capital asset pricing model: elementary discussion.	15
IV	Forwards and futures; options; European call and put options; payoff diagrams; put-call parity; binomial option pricing model; risk-neutral valuation: elementary introduction; hedging: basic idea.	10
V	Random variables in finance; expected value and variance; random walk models; Brownian motion: introductory idea; Black-Scholes model: assumptions and statement; limitations of models; computational implementation of basic financial models.	12
	Total Suggested Lectures	**60** (For 4 Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. John C. Hull, Options, Futures, and Other Derivatives, Pearson.
2. Sheldon M. Ross, An Elementary Introduction to Mathematical Finance, Cambridge University Press.
3. Marek Capinski and Tomasz Zastawniak, Mathematics for Finance, Springer.
4. David G. Luenberger, Investment Science, Oxford University Press.

C.7 Reference Books & Suggested Readings

1. Steven E. Shreve, Stochastic Calculus for Finance I, Springer.
2. Paul Wilmott, Paul Wilmott Introduces Quantitative Finance, Wiley.
3. Robert L. McDonald, Derivatives Markets, Pearson.
4. Mark S. Joshi, The Concepts and Practice of Mathematical Finance, Cambridge University Press.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

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Vijayath Kumar 18/06/26

Vikash Jha 15/6/26

Kaushal 15/6/26

C.1 MSMAT-CC 201: Linear Algebra

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 201
Title of the Paper	Linear Algebra
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester II
Nature of Course	Core Course (CC)
L - T – P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To develop structural understanding of finite-dimensional linear operators.
COB 2	To introduce minimal polynomial, primary decomposition and canonical forms.
COB 3	To study Jordan and rational canonical forms.
COB 4	To develop spectral theory in finite-dimensional inner product spaces.
COB 5	To introduce bilinear and quadratic forms.

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Vipul Sneh. 15/6/26

Sanjiv 15/6/26

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain invariant subspaces, minimal polynomials and primary decomposition.
CLO 2	Demonstrate computation of Jordan and rational canonical forms.
CLO 3	Analyze self-adjoint, normal, unitary and orthogonal operators.
CLO 4	Evaluate bilinear and quadratic forms.
CLO 5	Develop applications of canonical forms in differential equations and computation.

C.5 Syllabus - Unit-wise Breakdown

Course Name: LINEAR ALGEBRA (MSMAT-CC201)		
Unit	**Content**	**Suggested Lecture Hours**
I	Linear space, Basis and dimension;Subspaces; cyclic subspaces; annihilating polynomials; minimal polynomial; characteristic polynomial; Cayley-Hamilton theorem; relation between minimal polynomial and diagonalizability; primary decomposition theorem; triangular form.	15
II	Generalized eigenvectors; nilpotent operators; Jordan chains; Jordan blocks; existence of Jordan canonical form over algebraically closed fields; computation of Jordan form; geometric and algebraic multiplicities.	10
III	Companion matrices; cyclic decomposition theorem; invariant factors; elementary divisors; rational canonical form; relation between rational and Jordan canonical forms; Smith normal form: introduction; classification of linear operators over arbitrary fields.	10
IV	Inner product spaces; orthogonal complements; orthogonal projections; adjoint of a linear operator; self-adjoint operators; normal operators; unitary and orthogonal operators; spectral theorem for normal operators; spectral theorem for real symmetric matrix.	10
V	Dual spaces; dual basis; bilinear forms; symmetric and skew-symmetric bilinear forms; matrix of a bilinear form; change of basis; quadratic forms; diagonalization of quadratic forms; Sylvester's law of inertia; positive definite and semi-definite forms; canonical forms of quadratic forms.	15
	Total Suggested Lectures	**60** (For 4Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. Kenneth Hoffman and Ray Kunze, Linear Algebra, Prentice Hall.
2. Sheldon Axler, Linear Algebra Done Right, Springer.
3. Paul R. Halmos, Finite-Dimensional Vector Spaces, Springer.
4. Serge Lang, Linear Algebra, Springer.

C.7 Reference Books & Suggested Readings

1. Friedberg, Insel and Spence, Linear Algebra, Pearson.
2. Peter D. Lax, Linear Algebra and Its Applications, Wiley.
3. Horn and Johnson, Matrix Analysis, Cambridge University Press.
4. Roman, Advanced Linear Algebra, Springer.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

C.1 MSMAT-CC 202: Advanced Real Analysis

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 202
Title of the Paper	Advanced Real Analysis
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester II
Nature of Course	Core Course (CC)
L - T - P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

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C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To study absolute convergence, conditional convergence and rearrangements of infinite series.
COB 2	To develop rigorous understanding of sequences and series of functions.
COB 3	To analyse uniform convergence and its relation with continuity, integration and differentiation.
COB 4	To introduce Fourier series and convergence of trigonometric expansions.
COB 5	To develop differential calculus of functions of several variables at postgraduate level.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain absolute convergence, conditional convergence and rearrangement of series.
CLO 2	Demonstrate convergence properties of sequences and series of functions.
CLO 3	Analyze uniform convergence and justify interchange of limit, integration and differentiation.
CLO 4	Evaluate Fourier coefficients and analyse convergence of Fourier series.
CLO 5	Develop differential calculus of functions of several variables, including differentiability, inverse and implicit function theorems.

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C.5 Syllabus - Unit-wise Breakdown

Course Name: ADVANCED REAL ANALYSIS (MSMAT-CC202)		
Unit	**Content**	**Suggested Lecture Hours**
I	Infinite series; Integral test for series of arbitrary terms, Euler's constant, Riemann's and Pringsheim theorem on rearrangement of terms of conditionally convergent series, Abel's test and Dirichlet's test for arbitrary terms series. Power series, radius of convergence and basic properties.	12
II	Pointwise convergence and uniform convergence of sequences of functions; uniform convergence and properties; Dini's theorem: statement and applications; series of functions; pointwise and uniform convergence of series of functions; Weierstrass M-test; Abel's test and Dirichlet's test for uniform convergence;	16
III	Fourier series of periodic functions; even and odd extensions; Fourier sine and cosine series; Dirichlet conditions; pointwise convergence of Fourier series; convergence at points of discontinuity.	12
IV	Functions of several variables; linear transformation as a derivative; derivatives in open subsets; chain rule; partial derivatives; interchange of order of differentiation; derivatives of higher order; Taylor's theorem.	10
V	Inverse function theorem; implicit function theorem; rank theorem; local extrema of functions of several variables; Hessian matrix; constrained extrema; method of Lagrange multipliers.	10
	Total Suggested Lectures	**60** (For 4 Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill.
2. T. M. Apostol, Mathematical Analysis, Narosa.
3. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, Wiley.
4. S. C. Malik and Savita Arora, Mathematical Analysis, New Age International.

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C.7 Reference Books & Suggested Readings

1. Charles Chapman Pugh, Real Mathematical Analysis, Springer.
2. Kenneth A. Ross, Elementary Analysis: The Theory of Calculus, Springer.
3. Terence Tao, Analysis I, Hindustan Book Agency.
4. Tom M. Apostol, Calculus, Volume II, Wiley.
5. Michael Spivak, Calculus on Manifolds, CRC Press.
6. Elon L. Lima, Analysis on Manifolds, Springer.
7. Gerald B. Folland, Fourier Analysis and Its Applications, American Mathematical Society.
8. E. M. Stein and R. Shakarchi, Fourier Analysis: An Introduction, Princeton University Press.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

C.1 MSMAT-CC 203: Integral Equations

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 203
Title of the Paper	Integral Equations
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester II
Nature of Course	Core Course (CC)
L - T - P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

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C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To classify integral equations and study their basic structures.
COB 2	To develop methods for Fredholm and Volterra integral equations.
COB 3	To introduce resolvent kernels and successive approximation.
COB 4	To study eigenvalue problems for integral equations.
COB 5	To connect integral equations with differential equations and boundary value problems.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain classification and structure of integral equations.
CLO 2	Demonstrate methods for solving Fredholm and Volterra equations.
CLO 3	Analyze resolvent kernels and Neumann series.
CLO 4	Evaluate eigenvalue problems and Fredholm alternative.
CLO 5	Develop connections between integral equations and differential equations.

C.5 Syllabus - Unit-wise Breakdown

Course Name: INTEGRAL EQUATIONS (MSMAT-CC 203)		
Unit	**Content**	**Suggested Lecture Hours**
I	Integral equations and their classification; Fredholm integral equations of first and second kind; Volterra integral equations of first and second kind; homogeneous and non-homogeneous equations; kernels; separable kernels; symmetric kernels; singular kernels: introduction.	12
II	Fredholm integral equations with separable kernels; reduction to systems of linear equations; Fredholm determinant: introduction; Fredholm alternative: statement and applications; eigenvalues and eigenfunctions; solution of non-homogeneous equations; examples and applications.	10

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Ashish 25/2/26

III	Successive approximation method; Volterra equations with continuous kernels; resolvent kernel for Volterra equations; Neumann series; convolution kernels; Laplace transform method for Volterra integral equations; applications to initial value problems.	15
IV	Integral operators on function spaces; compactness: introductory idea; symmetric kernels; Hilbert-Schmidt theorem: statement and applications; orthogonal expansion of kernels; eigenfunction expansions; connection with Sturm-Liouville problems.	15
V	Conversion of differential equations into integral equations; Green's functions and boundary value problems.	08
	Total Suggested Lectures	**60** (For 4 Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. R. P. Kanwal, Linear Integral Equations: Theory and Technique, Birkhauser.
2. F. G. Tricomi, Integral Equations, Dover.
3. Abdul J. Jerri, Introduction to Integral Equations with Applications, Wiley.
4. M. D. Raisinghania, Integral Equations and Boundary Value Problems, S. Chand.

C.7 Reference Books & Suggested Readings

1. K. E. Atkinson, The Numerical Solution of Integral Equations of the Second Kind, Cambridge University Press.
2. Porter and Stirling, Integral Equations: A Practical Treatment, Cambridge University Press.
3. C. Corduneanu, Integral Equations and Applications, Cambridge University Press.
4. Wazwaz, Linear and Nonlinear Integral Equations, Springer.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

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C.1 MSMAT-CC 204: Mathematical Software

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-CC 204
Title of the Paper	Mathematical Software
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester II
Nature of Course	Core Course (CC)
L - T - P	0-0-4
Credits	4
Maximum Marks	120 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	-	70	-	70
Practical / Lab Work	-	Applicable	Applicable	Applicable
Internal Assessment	-	-	30	30
Maximum Marks	-	70	30	100
Passing Marks	-	32	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

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C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	Develop computational proficiency in mathematics through the effective use of mathematical software tools.
COB 2	Equip students with the ability to perform symbolic computations for solving algebraic and analytical problems.
COB 3	Equip students with the ability to perform symbolic computations for solving algebraic and analytical problems.
COB 4	Enhance numerical computation skills by applying appropriate computational techniques to mathematical problems.
COB 5	Provide training in graphical representation and visualization, enabling students to interpret and analyze mathematical concepts effectively.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain the role of MATLAB and Mathematica in modern mathematical computation.
CLO 2	Demonstrate symbolic and numerical computation using Mathematica and MATLAB.
CLO 3	Analyze mathematical problems through matrix operations, calculus tools and graphical visualization.
CLO 4	Evaluate computational outputs with correct mathematical interpretation.
CLO 5	Develop a reproducible computational project using MATLAB or Mathematica with code, output and explanation.

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C.5 Syllabus - Unit-wise Breakdown

Course Name: MATHEMATICAL SOFTWARE (MSMAT-CC 204)

Unit	Content	Suggested Lecture Hours
I	Basic interface of MATLAB and Mathematica; arithmetic operations; variables; built-in functions; expressions; lists; writing simple commands; scripts and notebooks; saving, documenting and exporting work.	24
II	Expansion and factorization of algebraic expressions; solving algebraic and transcendental equations; higher order derivatives; partial derivatives; integration; definite and indefinite integrals; limits; sequences and series; Taylor and power series expansions.	24
III	Numerical arithmetic; floating point computation; round-off error and truncation error; vectors and matrices in MATLAB; matrix addition, multiplication, transpose and inverse; determinant, rank, trace and eigenvalues; solution of systems of linear equations.	24
IV	Two-dimensional plotting in MATLAB and Mathematica; plotting polynomial, rational, trigonometric, exponential and logarithmic functions; parametric plots; polar plots.	24
V	Introduction to vectors in MATLAB; creating vectors using direct entry, colon operator and linspace command; basic vector operations; vector addition and subtraction; scalar multiplication; dot product; cross product; norm of a vector; distance between two vectors; unit vector; angle between two vectors; element-wise operations on vectors.	24
	Total Suggested Lectures	**120** (For 4 Credit Course)

Suggested Practical List

1. Use Mathematica to simplify, expand and factor algebraic expressions.
2. Use Mathematica to solve algebraic and transcendental equations symbolically and numerically.
3. Use Mathematica to compute limits, derivatives, integrals and series expansions.
4. Use Mathematica to verify selected identities from algebra, calculus and analysis.
5. Use MATLAB to perform vector and matrix operations.
6. Use MATLAB to compute determinant, rank, inverse, eigenvalues and eigenvectors.
7. Use MATLAB to solve systems of linear equations.
8. Use MATLAB to implement bisection method or Newton-Raphson method.
9. Use MATLAB to perform interpolation and curve fitting.
10. Use MATLAB or Mathematica to plot functions of one variable and two variables.
11. Use MATLAB or Mathematica to draw parametric curves, polar curves, surfaces and contour plots.
12. Use MATLAB or Mathematica to visualize convergence of sequences and series.
13. Use MATLAB to plot direction fields and phase portraits for simple differential equations.
14. Prepare one mini project using MATLAB or Mathematica on a mathematical topic from analysis, algebra, differential equations, numerical methods or modelling.

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Vikash Singh 15/6/26

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C.6 Prescribed Textbooks / Essential Readings

1. Stephen J. Chapman, MATLAB Programming for Engineers, Cengage.
2. Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Oxford University Press.
3. Stephen Wolfram, The Mathematica Book, Wolfram Media.
4. Paul R. Wellin, Programming with Mathematica: An Introduction, Cambridge University Press.

C.7 Reference Books & Suggested Readings

1. Brian R. Hunt, Ronald L. Lipsman and Jonathan M. Rosenberg, A Guide to MATLAB for Beginners and Experienced Users, Cambridge University Press.
2. Stormy Attaway, MATLAB: A Practical Introduction to Programming and Problem Solving, Elsevier.
3. Martha L. Abell and James P. Braselton, Mathematica by Example, Academic Press.
4. Cliff Hastings, Kelvin Mischo and Michael Morrison, Hands-on Start to Wolfram Mathematica, Wolfram Media.
5. Eugene Don, Schaum's Outline of Mathematica, McGraw-Hill.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

C.1 MSMAT-GE 201A: Graph Theory

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-GE 201A
Title of the Paper	Graph Theory
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester II
Nature of Course	Generic/Open Elective (GE/OE) - Option A
L - T - P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

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Vijayesh Kumar 15/06/26

Vipul Sneh 15/6/26

Sunil 15/6/26

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To introduce fundamental concepts and structures of graphs.
COB 2	To develop understanding of trees, connectivity and planarity.
COB 3	To study graph colouring, matching and vertex-cover concepts.
COB 4	To introduce graph matrices and network representations.
COB 5	To develop applications of graph theory to discrete and applied problems.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain fundamental graph-theoretic concepts and structures.
CLO 2	Demonstrate properties of trees, connectivity and planarity.
CLO 3	Analyze colouring, matching and domination problems.
CLO 4	Evaluate graph algorithms and network models.
CLO 5	Develop applications of graph theory to discrete and applied problems.

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Vinayak Kumar 15/06/26

Vibhuti Nath 15/6/26

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C.5 Syllabus - Unit-wise Breakdown

Course Name: GRAPH THEORY (MSMAT-GE 201A)		
Unit	**Content**	**Suggested Lecture Hours**
I	Graphs, multigraphs and directed graphs; degree sequence; isomorphism; subgraphs; walks, trails, paths and cycles; connectedness; cut vertices and bridges; Eulerian and Hamiltonian graphs; distance and diameter.	15
II	Trees; characterizations of trees; spanning trees; rooted trees; binary trees; minimal spanning trees.	10
III	Planar graphs; Euler formula; Kuratowski theorem: statement; dual graphs; graph colouring; chromatic number; chromatic polynomial: introduction; edge colouring; four colour theorem.	15
IV	Matchings; maximal and maximum matching; Hall theorem; bipartite matching; vertex covers.	10
V	Graph matrices; adjacency matrix; incidence matrix; Laplacian matrix.	10
	Total Suggested Lectures	**60** (For 4 Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall.
2. Douglas B. West, Introduction to Graph Theory, Pearson.
3. J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, Elsevier.
4. R. Diestel, Graph Theory, Springer.

C.7 Reference Books & Suggested Readings

1. F. Harary, Graph Theory, Addison-Wesley.
2. Chartrand and Zhang, Introduction to Graph Theory, McGraw-Hill.
3. Bela Bollobas, Modern Graph Theory, Springer.
4. Jonathan L. Gross and Jay Yellen, Graph Theory and Its Applications, CRC Press.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

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C.1 MSMAT-GE 201B: Fuzzy Theory

C.1 Paper Identification

PAPER PROFILE	
Paper Code	MSMAT-GE 201B
Title of the Paper	Fuzzy Theory
Programme / Subject	M.A / MSc. Mathematics
Semester	Semester II
Nature of Course	Generic/Open Elective (GE/OE) - Option B
L - T - P	3-1-0
Credits	4
Maximum Marks	100 (ESE: 70 + Internal Assessment: 30)
Duration of Examination	3 Hours

C.2 Marks Distribution

Component	Paper I	Practical	IA	Total
End Semester Examination	70	-	-	70
Practical / Lab Work	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Internal Assessment	-	-	30	30
Maximum Marks	70	-	30	100
Passing Marks	32	-	13	45 (45%)

Internal Assessment shall be conducted on the basis of class tests/mid-semester tests, assignments/problem sheets/written submissions, seminars/viva/oral discussion, attendance and class participation as provided in the regulation.

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Kalpana Srivastava
Officer on special duty (Judicial)

C.3 Course Objectives (COBs)

COB No.	Course Objective
COB 1	To introduce fuzzy sets and membership functions.
COB 2	To develop understanding of operations on fuzzy sets and fuzzy relations.
COB 3	To study fuzzy numbers, alpha-cuts and fuzzy arithmetic.
COB 4	To introduce fuzzy logic, fuzzy propositions and inference models.
COB 5	To develop fuzzy models for decision-making and uncertainty-based applications.

C.4 Course Outcomes (COs)

CLO No.	Course Learning Outcome
CLO 1	Explain fuzzy sets and membership functions.
CLO 2	Demonstrate operations on fuzzy sets and fuzzy relations.
CLO 3	Analyze fuzzy numbers and fuzzy arithmetic.
CLO 4	Evaluate fuzzy logic and fuzzy inference systems.
CLO 5	Develop fuzzy models for decision-making and uncertainty-based applications.

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Kalpana Srivastava
Officer on special duty (Judicial)

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C.5 Syllabus - Unit-wise Breakdown

Course Name: FUZZY THEORY (MSMAT-GE201B)		
Unit	**Content**	**Suggested Lecture Hours**
I	Classical sets; fuzzy sets and Crisp sets; membership functions; support, core and height; normal and convex fuzzy sets; operations on fuzzy sets; complement, union and intersection; properties of fuzzy set operations.	15
II	Crisp and fuzzy relations; operations on fuzzy relations; composition of fuzzy relations; equivalence and compatibility relations; fuzzy ordering relations; transitive closure.	10
III	Fuzzy numbers; triangular and trapezoidal fuzzy numbers; alpha-cut representation; arithmetic operations on fuzzy numbers; ranking of fuzzy numbers: introduction; fuzzy equations.	15
IV	Fuzzy propositions; linguistic variables; fuzzy truth values; fuzzy implications; Takagi-Sugeno model: introduction; defuzzification methods.	10
V	Fuzzy decision-making; multi-criteria decision-making: introduction; fuzzy matrices; fuzzy graphs.	10
	Total Suggested Lectures	**60** (For 4 Credit Course)

C.6 Prescribed Textbooks / Essential Readings

1. H. J. Zimmermann, Fuzzy Set Theory and Its Applications, Springer.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall.
3. Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley.
4. M. Ganesh, Introduction to Fuzzy Sets and Fuzzy Logic, Prentice Hall of India.

C.7 Reference Books & Suggested Readings

1. L. A. Zadeh, Selected Papers on Fuzzy Sets and Fuzzy Logic.
2. K. H. Lee, First Course on Fuzzy Theory and Applications, Springer.
3. Dubois and Prade, Fuzzy Sets and Systems, Academic Press.
4. Nguyen and Walker, A First Course in Fuzzy Logic, CRC Press.

C.7 Suggested E-Resources / Digital Repositories

1. SWAYAM / NPTEL courses relevant to postgraduate Mathematics and mathematical software.
2. e-PG Pathshala subject resources in Mathematics and allied disciplines.
3. Shodhganga / Shodhgangotri for thesis and dissertation reference.
4. National Digital Library of India (NDLI) for e-books, lectures and open learning materials.
5. arXiv, MathSciNet, zbMATH, Google Scholar and institutional repositories for research literature, wherever academically appropriate.

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C.8 Assessment Pattern & Question Paper Design

The End-Semester shall be conducted as per the following question paper design:

- Section A: Short Answer Questions (10 × 2 marks = 20 marks) — Covering all units (mandatory)
- Section B: Medium Answer Questions (4 × 5 marks = 20 marks) — Attempt any 4 out of 6
- Section C: Long Answer / Essay Questions (3 × 10 marks = 30 marks) — Attempt 3 out of 5.

Internal Assessment (30 marks) breakdown:

- Written Test(s): 20 marks
- Seminar / Assignment / Project: 05 marks
- Attendance & Class Participation: 05 marks

Note: *Generic/Open Elective–I (Course Code) and II (Course Code) courses in Semester- I and Generic/Open Elective–III (Course Code) and IV (Course Code) courses in Semester- II of 2 Year Postgraduate Programme may be offered by an institution based on student demand, academic interest, and the availability of qualified faculty members. These courses shall be open to students of the concerned discipline as well as students from other disciplines, with the objective of promoting multidisciplinary and interdisciplinary learning in accordance with the principles of the National Education Policy (NEP), 2020.*

For fulfilment of the programme requirements, a student shall be required to successfully complete any one of the Generic Elective courses offered during the semester. The institution may decide to offer either or both of the Generic Elective courses, subject to academic feasibility, availability of faculty expertise, and student enrolment.

D PART D — GENERAL REGULATIONS & PROVISIONS

D.1 Attendance & Eligibility

- A student must have a minimum of 75% attendance in each paper to be eligible to appear in the Semester / Annual Examination.
- Condonation of attendance deficiency shall be governed by the Regulation..
- A student detained due to shortage of attendance may appear to the examinations of same semester in the next academic session subject to payment of prescribed fees.

D.2 Examination & Promotion Rules

- A student is required to clear **at least** 60% (4 out of 6) papers of a particular Semester before being promoted to the succeeding Semester.
- Back / Ex-Student candidates shall be governed by the rules in force at the time of their original admission unless otherwise specifically notified.
- A candidate who fails in one or more papers shall be required to appear only in the failed paper(s) (Carry Forward System) in subsequent examinations of the same Semester.
- A candidate is required to clear all his/her papers within a maximum of **Five Years of duration** to qualify for the degree.

24/07/26
(Kalpana Srivastava)
Officer-On-Special Duty (Judl.)

Vijayath kumar 15/06/26

Vipul Shah. 15/6/26

8/6/26

D.3 Grading System (CBCS)

Letter Grade	% Range	Grade Point	Performance Description	Remarks
O	≥90-100	10	Outstanding	Pass
A+	≥80<90	9	Excellent	Pass
A	≥70<80	8	Very Good	Pass
B+	≥60<70	7	Good	Pass
B	≥55<60	6	Above Average	Pass
C	≥50<55	5	Average	Pass
P	≥45<50	4	Pass	Pass
F	<45	0	Fail	Fail
Ab/M	0	0	Absent/Malpractice	Fail / Reappear

E PART E — ABBREVIATIONS & AUTHENTICATION

E.1 List of Abbreviations

Abbr.	Expansion	Abbr.	Expansion
CC	Core Course	**DSE**	Discipline Specific Elective
GE	Generic Elective	**OE**	Open Elective
AEC	Ability Enhancement Course	**VAC**	Value Added Course
SEC	Skill Enhancement Course	**IKS**	Indian Knowledge System
L	Lecture (hours per week)	**T**	Tutorial (hours per week)

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Officer on special duty (Judicial)

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P	Practical (hours per week)	**IA**	Internal Assessment
CCA	Continuous & Comprehensive Assess.	**CLO**	Course Learning Outcome
PLO	Programme Learning Outcome	**GA**	Graduate Attribute
NHEQF	National HE Qualifications Framework	**PROJ**	Project / Dissertation

E.2 Authentication

Dr. Avinash Kumar	**Dr. Vipul Snehi**	**Dr. S.B. Rai**
Department of Mathematics	University Dept. of Mathematics	Department of Mathematics
Patna College, P.U., Patna	L.N.M.U, Darbhanga	Patna University, Patna
Subject Expert-3	**Subject Expert-2**	**Subject Expert-1**

Date: 15.06.2026

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Kalpana Srivastava
Officer on special duty (Judicial)