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STRUCTURE FOR COURSE OF STUDY

POSTGRADUATE PROGRAMME
AS PER

NATIONAL EDUCATION POLICY-2020
&
CURRICULUM AND CREDIT FRAMEWORK FOR POSTGRADUATE PROGRAMMES-2024

M.Sc. Mathematics
(w.e.f. Session 2026-27)



DEPARTMENT OF MATHEMATICS & STATISTICS
GURUKULA KANGRI (DEEMED TO BE UNIVERSITY)
HARIDWAR
2026

Curriculum Structure for Two-Year Post Graduate Programme
As per
National Education Policy-2020
Programme: M.Sc. Mathematics
(Effective from Session 2026-27)

Sem.	Classification	Paper Code	Paper Title	Credits	L	T	P	Level
I	DSC	MMA26-C101	**ADVANCED REAL ANALYSIS**	**4**	**45**	**15**	**-**	**400-499**
	DSC	MMA26-C102	**COMPLEX ANALYSIS**	**4**	**45**	**15**	**-**	**400-499**
	DSC	MMA26-C103	**ABSTRACT ALGEBRA**	**4**	**45**	**15**	**-**	**400-499**
	DSC	MMA26-C104	**ADVANCED DIFFERENTIAL EQUATIONS**	**4**	**45**	**15**	**-**	**400-499**
	DSC	MMA26-C105	**INTEGRAL EQUATIONS**	**4**	**45**	**15**	**-**	**400-499**
	HL	MMA26-H161	**LAB BASED COURSE-1 (Optional)**	**2**	**-**	**-**	**60**	**400-499**
II	DSC	MMA26-C201	**TOPOLOGY**	**4**	**45**	**15**	**-**	**400-499**
	DSC	MMA26-C202	**FIELD THEORY**	**4**	**45**	**15**	**-**	**400-499**
	DSC	MMA26-C203	**OPTIMIZATION TECHNIQUES**	**4**	**45**	**15**	**-**	**400-499**
	DSE (Any two out of floated courses)	MMA26-E201*	**PROGRAMMING IN C**	**3**	**36**	**9**	**-**	**400-499**
		MMA26-E251*	**LAB COURSE WITH C**	**1**	**-**	**-**	**30**	**400-499**
		MMA26-E202	**CALCULUS OF VARIATION**	**4**	**45**	**15**	**-**	**400-499**
		MMA26-E203	**DISCRETE MATHEMATICS**	**4**	**45**	**15**	**-**	**400-499**
		MMA26-E204	**BIO MATHEMATICS**	**4**	**45**	**15**	**-**	**400-499**
		MMA26-E205	**MOOC / ONLINE COURSE**	**4**	**45**	**15**	**-**	**400-499**
	HL	MMA26-H261	**LAB BASED COURSE-2 (Optional)**	**2**	**-**	**-**	**60**	**400-499**
EXIT OPTION-I: PG DIPLOMA								

*** The courses MMA26-E201 and MMA26-E251 will have to be opted together.**

STRUCTURE 1 (LEVEL 6.5) : PG CURRICULAR STRUCTURE WITH ONLY COURSE WORK								
Sem.	**Classification**	**Paper Code**	**Paper Title**	**Credits**	**L**	**T**	**P**	**Level**
III	DSC	MMA26-C301	**FUNCTIONAL ANALYSIS**	**4**	**45**	**15**	**-**	**500-599**
	DSC	MMA26-C302	**MEASURE THEORY & INTEGRATION**	**4**	**45**	**15**	**-**	**500-599**
	DSE (Any three out of floated courses)	MMA26-E301	**FUZZY SETS AND THEIR APPLICATIONS**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E302	**MATHEMATICAL STATISTICS-I**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E303	**COMBINATORIAL MATHEMATICS**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E304	**ALGEBRAIC NUMBER THEORY**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E305*	**PYTHON PROGRAMMING**	**3**	**36**	**9**	**-**	**500-599**
		MMA26-E351*	**LAB COURSE WITH PYTHON**	**1**	**-**	**-**	**30**	**500-599**
		MMA26-E306	**MOOC / ONLINE COURSE**	**4**	**45**	**15**	**-**	**500-599**
	INT	MMA26-I361	**INTERNSHIP (Optional)**	**2**				**500-599**
IV	DSC	MMA26-C401	**ADVANCED NUMERICAL ANALYSIS**	**4**	**45**	**15**	**-**	**500-599**
	DSC	MMA26-C402	**FOURIER SERIES & WAVELET ANALYSIS**	**4**	**45**	**15**	**-**	**500-599**
	DSE (Any three out of floated courses)	MMA26-E401	**MATHEMATICAL STATISTICS-II**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E402	**FRACTIONAL CALCULUS**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E403	**FINANCIAL MATHEMATICS**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E404	**SOFT COMPUTING**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E405	**GRAPH THEORY**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E406	**QUANTUM COMPUTING**	**4**	**45**	**15**	**-**	**500-599**
	HL	MMA26-H461	**LAB BASED COURSE-3 (Optional)**	**2**	**-**	**-**	**60**	**500-599**
COURSE COMPLETION: PG WITH ONLY COURSEWORK								

*** The courses MMA26-E305 and MMA26-E351 will have to be opted together.**

STRUCTURE 2 (LEVEL 6.5) : PG CURRICULAR STRUCTURE WITH COURSE WORK + RESEARCH								
Sem.	**Classification**	**Paper Code**	**Paper Title**	**Credits**	**L**	**T**	**P**	**Level**
III	DSC	MMA26-C301	**FUNCTIONAL ANALYSIS**	**4**	**45**	**15**	**-**	**500-599**
	DSC	MMA26-C302	**MEASURE THEORY & INTEGRATION**	**4**	**45**	**15**	**-**	**500-599**
	DSE (Any three out of floated courses)	MMA26-E301	**FUZZY SETS AND THEIR APPLICATIONS**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E302	**MATHEMATICAL STATISTICS-I**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E303	**COMBINATORIAL MATHEMATICS**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E304	**ALGEBRAIC NUMBER THEORY**	**4**	**45**	**15**	**-**	**500-599**
		MMA26-E305*	**PYTHON PROGRAMMING**	**3**	**36**	**9**	**-**	**500-599**
		MMA26-E351*	**LAB COURSE WITH PYTHON**	**1**	**-**	**-**	**30**	**500-599**
		MMA26-E306	**MOOC / ONLINE COURSE**	**4**	**45**	**15**	**-**	**500-599**
	HL	MMA26-H361	**LAB BASED COURSE-3 (Optional)**	**2**	**-**	**-**	**60**	**500-599**
IV	DIS/PR/PAT	MMA26-D471	**Dissertation***	**20**	**-**	**-**	**-**	**-**
COURSE COMPLETION: PG WITH COURSEWORK + RESEARCH								

*** The courses MMA26-E305 and MMA26-E351 will have to be opted together.**

STRUCTURE 3 (LEVEL 6.5) : RESEARCH								
Sem.	**Classification**	**Paper Code**	**Paper Title**	**Credits**	**L**	**T**	**P**	**Level**
III & IV	DIS/PR/PAT	MMA26-C471	One Intensive Problem Based Research*	**40**	**-**	**-**	**-**	**-**

The following outcomes must be achieved by the end of IVth Semester

1. Dissertation / Project Report certified by the Supervisor and Head of the Department which will be evaluated by the external examiner.
2. Attained at least one of the following outcomes:
   - I. Developed a prototype or product which meets the Technology Readiness
   - II. Publication in WoS/Scopus indexed journals or the journals recommended by the concerned Department; having the student as the first author and Supervisor (s) as corresponding author (s)
   - III. Patent Published / Granted
   - IV. Publication of Book by Reputed National / International Publisher
   - V. Any other specific and measurable research achievement as recommended by the BoS
     (a) Publication in Proceedings of Conference funded by Government Agencies / Scopus Indexed
     (b) Book Chapter indexed in Scopus / WoS

COURSE COMPLETION: PG WITH ONLY RESEARCH

***Dissertation / Research can be offered to those students securing more than 75% of marks up to IInd Semester and the availability of the requisite resources/ facility.**

NOTE: The Dissertation chosen should be an original work and not a repetition of work done in the 4th Year of the UG programme. It may be an extension of the work done in the 4th Year of UG programme.

EXAMINATIONS: The examinations of the courses will be done as per the Examination and Evaluation Policy of GK(DU).

ANNEXURE: YEAR/SEMESTER-WISE DISTRIBUTION OF CREDITS

1ST YEAR OF PG CURRICULAR STRUCTURE FOR 2 YEAR PG PROGRAMMES (3+2)						
Year	**Level**	**Semester**	**DSC (No. of course x Credits)**	**DSE (No. of course x Credits)**	**OPTIONAL 2 Credit Course (No. of course x Credits)**	**Total Credits Without Optional**
1	**6**	**I**	**5x4**	**--**	**1x2 [Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning]**	**20**
1	**6**	**II**	**3x4**	**2x4**	**1x2 [Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning]**	**20**

CURRICULAR STRUCTURES OF 2ND YEAR OF PG FOR TWO-YEAR PG PROGRAMME (3+2)
OR
ONE YEAR PG PROGRAMME AFTER COMPLETION OF FOUR-YEAR UG PROGRAMME (4+1)

STRUCTURE 1 (LEVEL 6.5) : PG CURRICULAR STRUCTURE WITH COURSEWORK ONLY						
Year	**Level**	**Semester**	**DSC (No. of course x Credits)**	**DSE (No. of course x Credits)**	**OPTIONAL 2 Credit Course (No. of course x Credits)**	**Total Credits Without Optional**
2	**6.5**	**III**	**2x4**	**3x4**	**1x2 Skill-based course/ workshop/ Specialised laboratory/ Internship/ Apprenticeship/ Hands on Learning**	**20**
2	**6.5**	**IV**	**2x4**	**3x4**	**1x2 Skill-based course/ workshop/ Specialised laboratory/ Internship/ Apprenticeship/ Hands on Learning**	**20**

STRUCTURE 2 (LEVEL 6.5): PG CURRICULAR STRUCTURE WITH COURSEWORK + RESEARCH						
Year	**Level**	**Semester**	**DSC (No. of course x Credits)**	**DSE (No. of course x Credits)**	**Research (Dissertation/ Project/ Patent)**	**Total Credits**
2	**6.5**	**III**	**2x4**	**3x4**	**--**	**20**
2	**6.5**	**IV**	**--**	**--**	**20**	**20**

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STRUCTURE 3 (LEVEL 6.5): RESEARCH							
Year	**Level**	**Semester**	**DSC (No. of course x Credits)**	**DSE (No. of course x Credits)**	**Optional**	**Research (Dissertation/ Project/ Patent) Credits**	**Total Credits**
2	**6.5**	**III & IV**	**--**	**--**	**--**	**40**	**40**

The following outcomes must be achieved by the end of IVth Semester

1. Dissertation/Project Report certified by the Supervisor and Head of the Department.
2. Attained at least one of the following outcomes:
   - I. Developed a prototype or product which meets the Technology Readiness
   - II. Publication in WoS/Scopus indexed journals or the journals recommended by the concerned Department; having the student as the first author and Supervisor (s) as corresponding author (s)
   - III. Patent
   - IV. Publication of Book by Reputed National/International Publisher
   - V. Any other specific and measurable research achievement as recommended by the BoS

NOTE: The Dissertation chosen should be an original work and not a repetition of work done in the 4th Year of the UG programme. It may be an extension of the work done in the 4th Year of UG programme.

EXAMINATIONS:

The examinations of the courses will be done as per the Examination and Evaluation Policy of GK (DU).

Programme Outcomes (POs)

On successful completion of the M.Sc. Mathematics programme, students will be able to:

- **PO-1: Advanced Mathematical Knowledge:** Acquire foundation knowledge to understand basics of mathematics and in-depth knowledge of various branches of pure and applied mathematics.
- **PO-2: Critical Thinking and Problem Solving:** Develop the capability to critically analyze complex mathematical problems, apply advanced mathematical principles, and formulate structured solutions.
- **PO-3: Analytical and Logical Reasoning:** Enhance abstract thinking, logical reasoning, and precision in establishing mathematical proofs, arguments, and structural relationships.
- **PO-4: Interdisciplinary Application:** Apply mathematical concepts and tools to diverse interdisciplinary fields such as Finance, Biology, Quantum Computing, Statistics, Soft Computing and AI.
- **PO-5: Research and Lifelong Learning:** Cultivate an aptitude for independent inquiry, continuous self-directed learning, and research-oriented thinking needed to adapt to emerging mathematical trends and MOOC frameworks.
- **PO-6: Professional Ethics and Communication:** Communicate complex mathematical arguments and results clearly, precisely, and effectively, both orally and in writing, while upholding academic and professional integrity.
- **PO-7**: **Employability options:** Work as academicians at post graduate, graduate and senior secondary levels apart from the researchers in the field of pure and applied mathematics.

Programme Specific Outcomes (PSOs)

After completing this specific M.Sc. Mathematics curriculum, the graduates will exhibit the ability to:

- **PSO-1: Mastery in Theoretical Core:** Core concepts from foundational abstract domains such as Real, Complex, Functional, and Lebesgue Analysis can be integrated effectively alongside Advanced Abstract Algebra and Topology to build rigorous structural mathematical frameworks.
- **PSO-2: Competence in Applied and Differential Analysis:** Model and evaluate real-world dynamic processes using the mathematical constructs developed in Advanced Differential Equations, Integral Equations, Fourier Transforms, and Fractional Calculus.
- **PSO-3: Optimization and Numerical Skillsets:** Apply algorithmic approaches, approximation methodologies, and advanced optimization techniques to formulate and solve complex multi-variable structural constraints in engineering, scientific, and business contexts.
- **PSO-4: Academic Aptitude and Readiness for National-Level Examinations:** Demonstrate a deep conceptual understanding and analytical skills necessary to qualify for national and state-level competitive examinations such as UGC/CSIR-NET, GATE, SLET, UPSC, and other public service or technical exams.
- **PSO-5: Computational and Digital literacy:** Utilize modern programming languages and mathematical software (such as Maxima, R, Python, and C) to simulate models, analyze statistical data and solve advanced numerical computations.

Title of the Course : ADVANCED REAL ANALYSIS
Course Code : MMA26-C101
Nature of the Course : DSC
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand the basic concept of Sequences and series, point-wise and uniform convergence of sequences of functions.

CO2: Acquire the knowledge and understanding the concepts of limit and continuity of functions and proves related theorems.

CO3: Learn concepts of the derivative of functions and acquire the knowledge of mean value theorems.

CO4: Analyze the properties of Riemann integrals of bounded functions via theorems.

UNITS	CONTENTS	L	T	P	Total Hours
1	Sequences of functions, pointwise and uniform convergence on interval, Cauchy's criterion for uniform convergence, M_n-test (result and exercises). Series of functions, pointwise convergence on interval, uniform convergence on interval, Weierstrass's M-test, Abel's test and Dirichlet's test (only tests result and exercises). Properties of uniformly convergent of sequences and series. Uniform convergence and continuity, Dini's theorem on uniform convergence (statement and exercises), Weierstrass approximation theorem (statement and exercise). Power series with some basic results and exercises.	13	4	-	17
2	Limit and continuity, algebra of limits, sequential approach of limit of function, Cauchy's criterion for finite limits (statement and exercise), continuity at a point, continuity (in/on) interval, types of discontinuity, uniform continuity (with basic results and exercises).	10	2	-	12
3	Derivative (derivability) at a point, derivative on interval (definition and exercises), relation between continuity and derivative, monotonic functions, Darboux's and intermediate theorems for derivatives (only statements), Rolle's, Lagrange's and Cauchy's mean value theorems (statements and exercises).	12	3	-	15
4	Partition, upper and lower (Darboux) sums of function, upper and lower integral of function, definition of Riemann integral, inequalities for Riemann integrals, refinement of partitions, Darboux's theorem (statement and exercise), conditions of integrability, integrability of the sum and difference of Riemann integrable functions, Riemann sums, primitive of function, fundamental theorems of integral calculus (statements and exercises). Definition of improper integral, integration of unbounded functions with finite limits of integration.	13	3	-	16
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. S. C. Malik and S. Arora, Mathematical Analysis, New Age International.
2. W. Rudin, Principles of Mathematical Analysis, McGraw Hill.
3. R. G. Bartle, The elements of integration and Lebesgue measure, Wiley Classics Library.
4. G.B. Folland, Real Analysis, Modern Techniques and Their Application, Wiley.
5. D. S. Kurtz and C. W. Swartz, Theories of Integration (Vol. 9), World Scientific.
6. D. A. Sprecher, Elements of Real Analysis, Academic Press, New York.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	1	2	3	2	1	2	2	1
CO2	3	2	2	2	2	2	3	2	2	2	2	1
CO3	2	3	2	2	2	2	3	1	2	2	2	1
CO4	3	2	2	2	1	2	2	2	1	2	2	-

Title of the Course : **COMPLEX ANALYSIS**
Course Code : **MMA26-C102**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Analyze the continuity and differentiability of complex functions and apply the concepts of analytic functions, Cauchy-Riemann equations, conjugate functions, and Milne Thomson's method for the construction of analytic functions.

CO2: Apply the principles of complex integration and fundamental theorems such as Cauchy-Goursat theorem, Cauchy's theorem, Morera's theorem, and Cauchy's integral formulae to solve problems in complex variables.

CO3: Examine the convergence of power series and represent complex functions using Taylor's and Laurent's series, and understand introductory conformal mappings including bilinear transformations.

CO4: Evaluate zeros, singularities, and residues of analytic functions, and apply residue theorems to compute contour integrals, real definite integrals, and integrals around the unit circle.

UNITS	CONTENTS	L	T	P	Total Hours
1	Continuity and differentiability of complex functions, Analytic and regular functions, Cauchy-Reimann equations, Necessary and sufficient conditions for a function to be analytic, some properties of conjugate functions, Construction of an analytic function, Milne Thomson's method.	12	3	-	15
2	Complex integration, Cauchy Goursat theorem, Cauchy's theorem, Morera's theorem, Cauchy's integral formulae, Cauchy inequalities, Liouville's theorem., Gauss mean value theorem, Maximum & minimum modulus theorems, Poisson's integral formulae,	12	3	-	15
3	Power series, The circle of convergence of the power series, Taylor's series, Laurent's series, Introductory conformal mapping (Bilinear transformation).	12	3	-	15
4	The zeros of an analytic function, Types of singularities, Residue at a single pole, Residue at a pole a of order greater than unity, Residue at infinity, Cauchy's residue theorem, Evaluation of real definite integral, Integral round the unit circle.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. B. Churchil, Fundamental of Complex Analysis
2. T. Pati, Fundamental of Complex Variable
3. J.H. Methews & R.W. Howell, Complex Analysis for Mathematics & Engineering, Narosa Pub.
4. Murry R. Spiegel, Complex Analysis, Schaum's Outline Series, McGraw-Hill Pub.
5. L.V. Ahlfors, Complex Analysis, McGraw-Hill.
6. J.B. Conway, Functions of One Complex Variable I, Springer-Verlag.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	2	3	3	2	2	3	1
CO2	3	3	3	3	3	2	2	3	2	2	3	1
CO3	3	3	3	3	3	2	3	3	2	2	3	1
CO4	3	3	3	3	3	2	3	3	2	3	3	1

Title of the Course : **ABSTRACT ALGEBRA**
Course Code : **MMA26-C103**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand the concepts of abstract mathematics, normal subgroups and analyze the structure of finite groups using conjugacy classes, the class equation, and Sylow's theorems.

CO2: Differentiate between different types of homomorphisms in groups, composition series and normal series of a group and understand commutator subgroup, solvable group and direct product.

CO3: Distinguish between various algebraic structures like integral domains, Euclidean rings and different types of ideals.

CO4: Demonstrate a comprehensive understanding of modules, submodules, direct sum, module homomorphism and quotient module.

UNITS	CONTENTS	L	T	P	Total Hours
1	Normal subgroups, Simple groups, Conjugacy, Normalization, Centre of a group, Class-equation of a group and its consequences, Theorems for finite groups, Cauchy's theorem, Sylow's theorems.	12	4	-	16
2	Homomorphisms, Endomorphisms, Automorphisms, Inner automorphisms, Group of automorphisms and Inner automorphisms, Maximal subgroups, Composition series, Jordan-Holder theorem, Normal series, Commutator subgroups, Solvable groups, Direct-Products of groups.	12	4	-	16
3	Rings, Sub-rings, Integral domain, Euclidean Rings, Ideal, Principal Ideal, Maximal and Prime ideals.	12	4	-	16
4	Modules, Submodules, Module homomorphism, linear and direct sum, finitely generated module, quotient module.	9	3	-	12
	Total (in Hrs)	45	15	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
2. J. B. Fraleigh, A First Course in Abstract Algebra, Pearson Education.
3. Mac-Donald, Theory of Groups and Fields, Clarendon Press.
4. J. A. Gallian, Contemporary Abstract Algebra, CRC Press, Taylor & Fransis Group.
5. V. K. Khanna and S. K. Bhambri, A Course in Abstract Algebra (Vikash Publications, III Edition).
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	3	2	3	3	1	1	3	1
CO2	3	3	3	2	3	2	3	3	1	1	3	1
CO3	3	3	3	1	3	2	3	3	1	1	3	1
CO4	3	3	3	2	3	2	3	3	1	1	3	1

Title of the Course : **ADVANCED DIFFERENTIAL EQUATIONS**
Course Code : **MMA26-C104**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Apply the properties and recurrence relations of Hermite and Laguerre polynomials
CO2: Analyze eigenfunctions, orthogonality properties and special functions arising in differential equations.
CO3: Understand orthogonal functions, orthonormalization and Sturm-Liouville problems.
CO4: Analyze and apply hypergeometric and confluent hypergeometric functions in solving higher-order differential equations and special function problems.

UNITS	CONTENTS	L	T	P	Total Hours
1	Hermite polynomials: Hermite equation and its solution, Generating function for Hermite polynomials, Rodrigue's formula for Hermite polynomials, Orthogonality properties of the Hermite polynomials, Recurrence relations.	12	3	-	15
2	Laguerre polynomial: Laguerre equation and its solution, Generating function for Laguerre polynomials, Orthogonal properties of Laguerres polynomials, Expansion of a polynomial in a series of Laguerre polynomials, Relation between Laguerre polynomial and their derivatives	12	3	-	15
3	Orthogonal set of functions and Sturm-Liouville problem: Orthogonality, Orthogonal set of function, Orthonormal set of functions, Orthogonality with respect to a weight function, Orthogonal set of functions with respect to a weight function, Orthogonal set of functions with respect to a weight function, Gram-Schmidt process of orthonormalization, Strum-Liouville problem, Eigen functions and eigen values, Orthogonality of eigenfunctions, Orthogonality of Legendre polynomials, Orthogonality of Bessel functions.	12	3	-	15
4	Hypergeometric function: General hypergeometric function, Confluent hypergeometric function, Hypergeometric function, Gauss's hypergeometric equation, Solution of hypergeometric equation, Symmetric property of hypergeometric function, Differentiation and Integral representation for hypergeometric function, Gauss theorem, Vandermonde's theorem, Kummer's theorem, Differentiation of confluent hypergeometric function, Integral representation for confluent hypergeometric function, Kummer's relation, Contiguous hypergeometric functions, Contiguous relationship, Contiguous relationship for confluent hypergeometric function.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.
SUGGESTED READINGS (LATEST EDITION):

1. N. N. Lebedev, Special Functions and Their Applications, Dover Publications.
2. E. T. Whittaker and G. N. Watson, A Course of Modern Analysis, Cambridge University Press.
3. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
4. G. F. Simmons, Differential Equations with Applications and Historical Notes, CRC Press.
5. G. E. Andrews, Richard Askey and Ranjan Roy, Special Functions, Cambridge University Press.
6. M. R. Spiegel, Theory and Problems of Differential Equations, McGraw Hill Education.
7. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Publishing.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	–	–	3	3	–	2	-
CO2	3	3	3	2	1	–	–	3	3	–	2	-
CO3	3	3	3	1	2	1	–	3	2	–	2	-
CO4	3	2	3	2	2	1	–	3	3	1	2	1

Title of the Course : **INTEGRAL EQUATIONS**
Course Code : **MMA26-C105**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Classify integral equations and convert differential equations into integral equations.
CO2: Apply iterative and successive approximation methods to solve Volterra and Fredholm integral equations.
CO3: Solve Fredholm integral equations with separable kernels using Fredholm theory and related theorems.
CO4: Use Laplace and Fourier transforms to solve special types of integral equations.

UNITS	CONTENTS	L	T	P	Total Hours
1	Definition of Integral Equations and their classifications, Eigen values and Eigen functions, Special kinds of Kernel, Convolution Integral, The inner or scalar product of two functions, Definition of Integral Equations and their classifications, Conversion of ordinary differential equations into integral equations by the method of IVP into Volterra integral equation and BVP into Fredholm integral equation.	12	3	-	15
2	Method of successive approximations, Resolvant kernel, Fredholm integral equation of second kind by successive substitutions and successive approximations, Iterative scheme for Fredholm and Volterrra Integral equations of the second kind, Neumann series. Conditions of uniform convergence and uniqueness of series solution. Some results about the resolvent Kernel. Application of iterative scheme to Volterra integral equations of the second kind, solution of homogeneous Fredholm integral equation of second kind with separable or degenerated kernel.	12	3	-	15
3	Fredholm integral equations of second kind with separable (or degenerate) kernels Fredholm alternative, Fredholm theorem, Fredholm alternative theorem, an approximate method,Classical Fredholm's theory, the method of solution of Fredholm equation, Fredholm's First theorem, Fredholm's second theorem, Fredholm's third theorem.	12	3	-	15
4	Solution of Integral Equations by Transform Methods: Laplace Transform, Some special types of integral equations, Applications of Laplace Transform to determine the solution of integral equation with convolution-type kernels, Fourier Transform, Applications of Fourier Transform to determine the solution of integral equation.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.
SUGGESTED READINGS (LATEST EDITION):

1. F.B. Hildebrand, Methods of Applied Mathematics, Prentice Hall.
2. L.B. Chambers, Integral Equations, International Text Book Co.
3. I.M. Gelfand, & S.V. Fomin, Calculus of Variations, Prentice Hall (Unit-III).
4. I.N. Sneddon, Integral Transforms, Schaum's Outline Series, McGraw-Hill Pub.
5. M.D. Raisinghania, Integral Equations, S. Chand Publishers.
6. B.S. Grewal, Engineering Mathematics, Khanna Publishers.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	–	–	2	3	–	2	–
CO2	3	3	3	2	2	–	–	2	3	1	2	–
CO3	3	3	3	2	2	1	–	2	3	1	2	–
CO4	3	3	2	3	2	1	–	2	3	1	2	1

Title of the Course : **TOPOLOGY**
Course Code : **MMA26-C201**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Understanding the concept of topological spaces and their role in mathematics.
CO2: Learn the elementary basic results on sets theory in topological spaces.
CO3: Acquire the knowledge on connectedness and compactness.
CO4: Describe many fundamental relationships on the separation axioms.

UNITS	CONTENTS	L	T	P	Total Hours
1	Topological Spaces: Definition and examples, some elementary concept, basis and sub basis for topology, elementary concept of basis, definitions of order topology, weak and strong topologies, projections, product topology, quotient topology, and meterizable space with examples, sub topological space and their basic concept, Hausdorff Space.	12	3	-	15
2	Elements of Topological Space: Open and closed sets in topological space with elementary concept, limit and isolated points, interior and exterior points of topological space, interior and closure of sets, elementary concept of interior and closure of sets, boundary of set, dense and it's elementary, perfect set and examples.	12	3	-	15
3	Connectedness: Continuity of function in topological space, construction of continuous functions, Pasting lemma, continuity theorems for open and closed sets, homeomorphism and its examples, connected space and examples, elementary of connectedness, connected spaces of the real lines, intermediate value theorem, definition of path and examples, components and path components, locally connected space, totally disconnected space.	12	3	-	15
4	Compactness and Separation Axioms: Compact space and examples, elementary results of compactness, compact spaces of the real lines limit point compactness, first and second countable space, T_1-Space, T_2-Space, regular spaces, normal spaces, Uryshon lemma.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. G. F. Simmons, Introduction to Topology and Modern Analysis, Robert E. Krieger Publishing Company, Malabar Florida.
2. J. Munkers, Topology: A First Course, Prentice Hall of India.
3. C. Adams and R. Franzosa, Introduction to Topology Pure & Applied, Dorling Kindersley India Pvt. Ltd. (Indian Edition).
4. S. Lipschutz, Theory and Problems of General Topology, Schaum's Outline Series, McGraw-Hill Pub.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	1	2	2	2	2	1	2	-
CO2	3	2	3	1	1	2	2	2	2	1	1	-
CO3	3	2	3	1	1	2	2	2	2	1	2	-
CO4	3	3	2	1	1	2	1	2	2	1	2	-

Title of the Course : **FIELD THEORY**
Course Code : **MMA26-C202**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Analyze irreducible polynomials, finite extension, algebraic extension and simple extension of a field and identify algebraically closed field.

CO2: Establish the relationships among polynomial rings, roots of polynomials and their splitting fields.

CO3: Understand concepts related to Galois theory such as fixed field, automorphism of a field, Galois group of a polynomial over a field and normal extension and analyze their relation using Galois fundamental theorem.

CO4: Test the solvability of polynomials by radicals, learn geometric construction with the help of straight edge and compass and relate finite extension fields and constructible numbers.

UNITS	CONTENTS	L	T	P	Total Hours
1	Irreducible polynomials, Extension fields, Transitivity of finite extensions, Algebraic element, Algebraic field extensions, Simple extension, Algebraic closure and algebraically closed field.	12	4	-	16
2	Roots of polynomials, Multiple roots, Minimal polynomials, Splitting field, Existence of SF of a polynomial, Separable extension, Perfect field.	12	4	-	16
3	Automorphism of a field, Fixed field, Finite field, Galois field, Group of Automorphism of a field K relative to its subfield, Galois group of a Polynomial over a field, Normal extension, Symmetric functions and elementary symmetric functions, Galois Fundamental theorem.	12	4	-	16
4	Solvability of polynomials by radicals over Q, Constructible numbers, Construction with straight edge and Compass.	9	3	-	12
	Total (in Hrs)	45	15	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
2. J. B. Fraleigh, A First Course in Abstract Algebra, Pearson Education.
3. Mac-Donald, Theory of Groups and Fields, Clarendon Press.
4. J. A. Gallian, Contemporary Abstract Algebra, CRC Press, Taylor & Fransis Group.
5. V. K. Khanna and S. K. Bhambri, A Course in Abstract Algebra, Vikash Pub.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	2	2	2	3	1	-	3	-
CO2	3	3	3	1	2	2	2	3	1	-	3	-
CO3	3	3	3	2	2	2	2	3	1	-	3	-
CO4	3	3	3	2	2	2	2	3	1	-	3	-

Title of the Course : **OPTIMIZATION TECHNIQUES**
Course Code : **MMA26-C203**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Solve integer programming problems and quadratic programming problems by employing various techniques.
CO2: Determine the optimal sequence of jobs on machines to minimize the processing time and apply the concepts of game theory to real world competitive situations to find out best strategy for optimizing gains/losses.
CO3: Determine waiting time and queue lengths of various queue disciplines.
CO4: Solve different types of inventory models.

UNITS	CONTENTS	L	T	P	Total Hours
1	Integer programming: Branch and bound technique, Gomory's fractional cut method. Non-linear Programming: Convex sets and convex functions, Quadratic programming, K-T conditions, Beale's methods.	12	4	-	16
2	Sequencing Theory: Introduction, Processing with n-jobs and two machines, n-jobs and three machines, n-jobs and m- machines, Concept of jobs blocks, Processing two jobs on m-machines. Game Theory: Saddle point, Solution of 2 x 2 games, Algebraic method, Graphical method for 2 x n and m x 2 games, Solution of m x n games by linear programming.	12	4	-	16
3	Queuing Theory: Introduction, Characteristics of queuing systems, Poisson process and Exponential distribution, Classification of queues, Transient and steady states, Poisson queues (M/M/1, M/M/C).	9	3	-	12
4	Inventory Management: Inventory control, Types of inventories, Cost associated with inventories, Factors affecting inventory control, Single item deterministic problems with and without shortages, Inventory control with price breaks, Inventory control for one period without setup cost with uncertain demands.	12	4	-	16
	Total (in Hrs)	45	15	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. M.S. Bazaraa, J.J. Jarvis and H.D. Sherali, Linear Programming and Network Flows, John Wiley and Sons, India.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, Tata McGraw Hill, Singapore.
3. H. A. Taha, Operations Research, An Introduction (8th Ed.), Prentice-Hall India.
4. P.K. Gupta, K. Swarup & M. Mohan, Operations Research, Sultan Chand & Co.
5. A.M. Natarajan, P. Balasubramani and A. Tamilarasi, Operations Research, Pearson Education, India.
6. R.L. Ackoff and N.W. Sasieni, Fundamental of Operations Research, John Wiley, New York
7. S.D. Sharma, Operations Research, Kedar Nath Ram Nath.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2	2	3	1	2	3	3	2
CO2	3	3	3	3	2	2	3	1	-	3	3	2
CO3	3	3	3	3	2	2	3	1	2	3	3	2
CO4	3	3	2	3	2	2	3	1	1	3	3	2

Title of the Course : **PROGRAMMING IN C**
Course Code : **MMA26-E201**
Nature of the Course : **DSE**
Total Credits : **03**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand different base number systems, and construct logical problem-solving frameworks using structured algorithms and flowcharts. Formulate and execute simple C programs by applying appropriate data types, tokens, operators, and input/output configurations while mastering operator precedence.

CO2: Design and implement complex decision-making, iterative looping cycles, and modular code structures using user-defined and recursive functions with proper scope management.

CO3: Analyze and manipulate multi-dimensional data arrays, text strings.

CO4: Build efficient programs using custom user-defined data types with file persistence.

UNITS	CONTENTS	L	T	P	Total Hours
1	Binary, Octal and Hexadecimal number systems, Problem solving algorithm, Flowcharts, Basic concepts of low level language and high level language, Compiler, Interpreter. Structure of a C program, Pre-processor directives, Character set, Tokens in C, Keywords and identifiers, Constants, Variables, Data types, Arithmetic operators, Relational operators, Logical operators, Assignment operator, Conditional operator, Operator precedence and associativity, expressions, Declaration and initialization of variables, Reading and writing characters, Reading and writing strings, Data I/O, Qualifiers, Coercion, Comments, Library functions.	12	3	-	15
2	Control statements: Decision making with IF, IF-ELSE, Nesting of IF-ELSE, ELSE-IF ladder, switch statement, 'for' loop, 'while' loop, 'do' loop, break, continue and goto statements. Simple functions, Passing arguments to functions and returning values from functions, Recursion, Storage classes, Scope and visibility of local and global variables.	12	3	-	15
3	Arrays Fundamentals, One-dimensional arrays, Two-dimensional arrays, Multi-dimensional arrays, Nesting of arrays, Passing arrays to functions, Strings, String handling functions, Array of strings. Structures, Arrays and structures within structures, Array of structures, Passing structures to functions, Unions, Reading from a file and writing in a file.	12	3	-	15
	Total (in Hrs)	36	9	-	45

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. B. W. Kernighan, D. M. Ritchie, The C Programming Language, Prentice Hall.
2. B. S. Gottfried, Theory and Problems of Programming with C, Schaum's Outline Series, McGraw-Hill.
3. E. Balagurusamy, Programming in ANSI C, Tata McGraw-Hill.
4. Y. Kanitkar, Let us C, B.P.B. Publications
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	3	2	3	-	2	3	3	3
CO2	2	3	3	3	3	2	3	-	2	3	3	3
CO3	2	3	3	3	3	2	3	-	2	3	3	3
CO4	1	3	3	3	3	2	3	-	2	3	3	3

Title of the Course : **LAB COURSE WITH C**
Course Code : **MMA26-E251**
Nature of the Course : **DSE**
Total Credits : **01**
Distribution of Marks : **30(Ext.) + 20(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Implement fundamental programming syntax and basic control flow.
CO2: Construct complex loops, nested patterns, and mathematical series computations.
CO3: Manipulate structured data arrays, matrices, and modular functions.
CO4: Build advanced structures, string handlings, and persistent data operations.

CONTENTS	L	T	P	Total Hours
The following practical will be done using the programming language C and record of those will be maintained in the practical file: **List of Programs in C** **1.** Write a program to find the volume of a room. **2.** Write a program to find greatest among three numbers. **3.** Write a program to check for an Armstrong number. **4.** Write a program to find the roots of quadratic equation. **5.** Write a program to print a pattern a b c a b a **6.** Write a program to print a pattern 1 1 2 1 1 2 3 2 1 **7.** Write a program to generate the reverse of a five-digit number. Check the number to be palindrome. **8.** Write a program to find the sum 1!+2!+3!+…n! **9.** Write a program to find the sum of first *n* terms of the series $x - \frac{x^3}{3!} + \frac{x^5}{5!} + \cdots$ **10.** Write a program to find the average of a list of *n* numbers. **11.** Write a program to find the trace of a square matrix and transpose of a matrix of order *m*x*n*. **12.** Write a program to add and multiply two matrices. **13.** Write a program to find the factorial of a number by recursion. **14.** Write a program to generate Fibonacci series using recursion. **15.** Write a program to sort a list of numbers in descending order. **16.** Write a program to search a number in an array by binary search method. **17.** Write a program to implement nested structures. **18.** Write a program to concatenate one string at the end of other string by means of user defined function as well as library function. Also compare the two outputs. **19.** Write a program to implement structure and union. **20.** Write a program to read from a file and write on a file.	-	-	30	30
Total (in Hrs)	-	-	30	30

MODES OF IN-SEMESTER ASSESSMENT: Practical Tests, Quiz etc.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	3	2	3	-	1	3	3	3
CO2	3	3	3	3	3	2	3	-	2	3	3	3
CO3	3	3	3	3	3	2	3	-	2	3	3	3
CO4	1	3	3	3	3	2	3	-	2	3	3	3

Title of the Course : **CALCULUS OF VARIATION**
Course Code : **MMA26-E202**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Understand the basic concepts of functionals, Euler's equations, and variational problems.
CO2: Apply variational techniques to solve fixed and moving boundary problems.
CO3: Analyze Hamilton's principle and canonical transformations in variational problems.
CO4: Evaluate variational problems using direct and numerical methods.
CO5: Develop mathematical models using calculus of variations for applied problems.

UNITS	CONTENTS	L	T	P	Total Hours
1	Variational problems with fixed boundaries: Introduction, Functionals, Euler's equation and its forms, Necessary and sufficient conditions for extremum, Higher order variational problems, Isoperimetric problems, Variational problems with several independent variables.	12	3	-	15
2	Variational problems with moving boundaries: Transversality conditions, Variational problems with moving boundaries, Generalised boundary conditions, One sided variations, Extremals with corners.	12	3	-	15
3	Applications and canonical transformations: Applications of calculus of variations, Principle of least action, Hamilton's principle, Lagrange's equations from Hamilton's principle, Canonical/contact transformations and canonical conditions.	12	3	-	15
4	Direct methods: Direct methods in variational problems, Ritz method, Galerkin method, Collocation method, Least square method, Kantorovich method, Problem solving.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. I. M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice-Hall of India Pvt.Ltd, New Delhi.
2. A. S. Gupta, Calculus of Variations with Applications, PHI Learning Pvt.Ltd., New Delhi.
3. H. Sagan, Introduction to the Calculus of Variations, Dover Publications, New York
4. B. S. Grewal, Higher Engineering Mathematics (Calculus of Variations chapters), Khanna Publishers, New Delhi.
5. M. D. Raisinghania, Calculus of Variations and Integral Equations, S. Chand Publishing House, New Delhi
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	–	–	3	2	–	2	–
CO2	3	3	3	2	1	–	–	2	3	1	2	–
CO3	3	3	3	3	2	1	–	2	3	2	2	–
CO4	2	3	3	2	3	1	–	2	2	2	2	1
CO5	3	3	3	3	3	1	1	2	3	3	2	1

Title of the Course : DISCRETE MATHEMATICS
Course Code : MMA26-E203
Nature of the Course : DSE
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand and apply the fundamental concepts of logic and propositional calculus, including logical operations, truth tables, logical equivalence, implications, and validity of arguments.

CO2: Analyze propositions and quantified statements using predicates, quantifiers, converse, inverse, contraposition, and methods of proving validity without truth tables.

CO3: Examine the structure and properties of partially ordered sets (POSet) and lattices, including order relations, Hasse diagrams, bounds, well-ordered sets, and different types of lattices.

CO4: Understand the concepts and algebraic properties of Boolean algebra, including Boolean functions, laws, isomorphism, duality, and canonical representations such as SOP, POS, DNF, and CNF forms.

CO5: Apply Boolean algebra and Karnaugh maps to simplify Boolean functions and design basic logic gate circuits using AND, OR, NOT, NAND, NOR, and XOR gates.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction to proposition (or statement) and compound propositions, basic logical operations (conjunction, disjunction and negation) and their truth tables, derived logical operations (NAND, NOR, XOR) and their truth tables, nature of compound propositions (as tautology, contradiction and contingency), algebra of propositions, conditional and bi-conditional statements, precedence of logical operations, principle of duality, logical equivalence and logical implications of compound propositions, converse, inverse and contra-positive of propositions.	12	3	-	15
2	Arguments and their nature (as valid and fallacy), elementary valid argument forms, proof of validity without using truth tables, predicates (or propositional functions) and their truth sets, free and binding variables, quantifiers, negation of quantified statements, relations, equivalence relation.	12	3	-	15
3	Partial order, dual order and quasi-order relation on a set, subsets of a partially ordered set (POSet), comparability of elements in a POSet, linear order, product order and lexicographical order on a set, Kleene closure of a set of alphabets, Hasse diagram of a POSet, various elements (first element, last element, lower bound, upper bound, minimal, maximal, supremum and infimum) in a POSet, well ordered set, lattices, sub-lattices, isomorphic lattices, bounded lattices, distributive lattices, elements (join irreducible, meet irreducible, atoms, anti-atoms, complements) in a lattice, complemented, modular and product lattices.	12	3	-	15
4	Unary and binary operations on a set, Boolean algebra and sub-algebra, elements of Boolean algebra, isomorphic Boolean algebras, basic laws for Boolean algebra, principle of duality, alternative definition of Boolean algebra, Boolean function, literal and fundamental products, sum-of-products(SOP) and product-of-sums(POS) forms, canonical and non-canonical forms of SOP and POS, complete SOP and POS forms, disjunctive normal form (DNF) and conjunctive normal form (CNF), minimal SOP and minimal POS, prime implicants, consensus of fundamental products, Boolean expansion theorem, determination of Boolean function from its truth table, logic gates (AND, OR, NOT, NAND, NOR, XOR) and circuits, Karnaugh maps (up to three variables).	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. B. Colman, R. C. Busby and S. Ross, Discrete Mathematical Structures, PHI.
2. K. H. Rosen, Discrete mathematics and its applications, McGraw-Hill.
3. S. Lipschutz and M. L. Lipson, Discrete Mathematics, Schaum's Outline Series, McGraw- Hill.
4. J. Gallier and J. Quaintance, Mathematical Foundations and Aspects of Discrete Mathematics, Springer.
5. U. S. Gupta, Discrete Mathematical Structure, Pearson Education.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	2	3	3	1	2	3	1
CO2	3	3	3	3	3	3	3	3	1	2	3	1
CO3	3	3	3	3	3	3	3	3	1	2	3	1
CO4	3	3	3	3	3	3	3	3	1	2	3	1
CO5	3	3	3	3	3	3	3	3	1	2	3	1

Title of the Course : BIO MATHEMATICS
Course Code : MMA26-E204
Nature of the Course : DSE
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand the concepts and applications of bio mathematical modelling in biological, medical, and environmental systems.

CO2: Apply mathematical models to population dynamics, epidemiology, microbial growth, and ecological interactions.

CO3: Analyze biological and medical systems using differential equations, optimization techniques, and stability analysis.

CO4: Evaluate mathematical models related to blood flow, patient care, and biomedical processes using advanced mathematical methods.

UNITS	CONTENTS	L	T	P	Total Hours
1	Discrete Bio mathematical Models: Introduction to bio mathematical modelling, role and scope of mathematical models in biosciences, classification of mathematical models, discrete population dynamics, mathematical ecology, mathematical bio economics, discrete epidemiological models, mathematical genetics, difference equation models, age-structured population models, Leslie matrix models and applications of discrete models in biological systems.	12	3	-	15
2	Discrete Optimization Models in Biology and Medicine: Role of optimization models in biology and medicine, linear programming formulations, nonlinear programming formulations, medical diagnosis problem, hospital diet problem, optimization models for blood testing and patient care, Dorfman procedure, Sterett procedure, Sobel-Groll procedure, Information Theory procedure, Dynamic Programming formulation for patient care.	12	3	-	15
3	Continuous Bio mathematical Models and Microbial Population Models: Continuous population dynamics, mathematical epidemiology, pharmacokinetics, mathematical physiology and biomechanics, microbial kinetics, microbial growth in a chemostat, stability of steady states for chemostat, growth of microbial populations, product formation due to microbial action, competition for a growth-rate limiting substrate in a chemostat, one rate limiting substrate: batch-culture case, a number of rate limiting substrates, commensalism, mutualism, predation and mutation.	12	3	-	15
4	Continuous Models for Blood Flow and Biomedical Systems: Basic concepts about blood, constitution of blood, viscosity of blood, cardiovascular system and blood flow, Navier–Stokes equation for the flow of a viscous incompressible fluid, Hagen–Poiseuille flow, steady non-Newtonian fluid flows in circular tubes, Newtonian pulsatile flows in rigid tubes, applications of fluid dynamics in biological and medical systems.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. J. N. Kapur, Mathematical Models in Biology and Medicine, East-West Press Pvt. Ltd., New Delhi.
2. N. Chandra and R. K. Pathak, Biomathematics, Narosa Publishing House, New Delhi.
3. L. Edelstein-Keshet, Mathematical Models in Biology, SIAM Publications Library.
4. J. D. Murray, Mathematical Biology, Springer.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	3	1	1	1	1	3	2	1	1
CO2	3	3	3	3	2	1	2	1	3	3	1	2
CO3	3	3	3	3	2	1	2	1	3	3	2	2
CO4	3	3	2	3	2	2	2	1	3	3	2	2

Title of the Course : **FUNCTIONAL ANALYSIS**
Course Code : **MMA26-C301**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Describe the Banach space, linear operators along with their algebraic properties.
CO2: Explain normed Space, compactness and finite dimension.
CO3: Understand the concept of bounded linear operators and bounded linear functional for finite dimension with its length.
CO4: Endow linear algebra with concepts from topology (inner product space, including principle of uniform boundedness, Hahn-Banach theorem, open mapping theorem, closed graph theorem).

UNITS	CONTENTS	L	T	P	Total Hours
1	Normed Spaces: Banach space, subspace of Banach space, elementary property of normed spaces, finite dimensional normed space and subspaces, compactness and finite dimension, linear operators, bounded and continuous linear operators. Linear functionals, linear operators and functional on finite dimensional spaces, normed spaces of operators, dual spaces.	14	4	-	18
2	Inner Product Spaces: Definition and examples, subspace, Schwarz inequality, orthogonal compliments and direct sums, Hilbert spaces, minimizing vector theorem, orthogonal projections, orthonormal basis, Riesz-representation theorem.	12	3	-	15
3	Special Operators: Hilbert-Adjoint operator, self-adjoint operators and its product, normal operators, unitary operators, spectral theorem for compact self-adjoint operators.	10	2	-	12
4	Four Theorems: Definition of sublinear functional and examples, Hahn-Banach theorem for normed space, boundedness of linear functional, definition of category, Baire's category theorem for metric space, uniform boundedness theorem, definitions of open mapping and closed graph, closed linear operator, open mapping theorem, closed graph theorem.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):
1. E. Kreyszig, Introductory Functional analysis with applications, John Wiley & Sons.
2. W. Rudin, Functional analysis, Mc Graw Hill Pub.
3. B.V. Limaye, Functional analysis, Wiley Eastern Ltd. New Delhi
4. T. Nair, Functional analysis, Prentice Hall.
5. P. K. Jain, O. P. Ahuja and K. Ahmed, Functional analysis, New Age International (P) Limited, New Delhi.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	-	2	3	3	3	2	1	1	-
CO2	3	3	2	-	2	2	3	3	3	2	2	1
CO3	2	2	3	2	1	3	2	1	1	2	1	-
CO4	3	3	2	2	1	2	1	2	2	1	2	-

Title of the Course : **MEASURE THEORY & INTEGRATION**
Course Code : **MMA26-C302**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Understand the concepts of measurable sets, outer measure, Borel sets, and properties of measurable sets.
CO2: Apply the concepts and properties of measurable functions, simple functions, and convergence in measure.
CO3: Analyze measurable functions using almost everywhere property, Egoroff's theorem, Lusin theorem, and related convergence concepts.
CO4: Evaluate Lebesgue integrals and important convergence theorems including Fatou's lemma, Monotone convergence theorem.

UNITS	CONTENTS	L	T	P	Total Hours
1	Equivalent sets, Countable and uncountable sets, Length of sets, Lebesgue outer measure of sets, Lebesgue measurable sets and their properties, Boolean algebra of sets, $\sigma-$Boolean algebra, Borel sets and their measurability, Characterization of measurable sets.	13	3	-	16
2	Measurable functions and their properties, Algebra of Measurable functions, Step function, Max and min functions, Positive and negative parts of a measurable function, Characteristics function, Simple function, Continuity of a function over measurable sets,	12	3	-	15
3	Sets of measure zero, Almost everywhere property, Egoroff's theorem, Lusin theorem, Frechet theorem, Convergence in measure, Fundamental in measure.	9	2	-	11
4	Lebesgue Integral of a bounded function, Relation between Riemann and Lebesgue Integrals, Properties of Lebesgue integrals on bounded measurable functions, Bounded convergence theorem, Integral of nonnegative measurable function, Fatou's lemma, Monotone convergence theorem.	14	4	-	18
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. G. de Barra, Measure Theory and Integration, Woodhead Publishing, New Delhi.
2. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International.
3. H. L. Royden, Real Analysis, Prentice Hall.
4. W. Rudin, Principles of Mathematical Analysis, McGraw Hill.
5. R. Bartle, The elements of integration and Lebesgue measure, Wiley Classics Library.
6. G. B. Folland, Real Analysis, Modern Techniques and Their Application, Wiley.
7. S. C. Malik and S. Arora, Mathematical Analysis, New Age International.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	–	1	3	2	–	1	–
CO2	3	3	2	1	1	–	1	3	2	1	2	–
CO3	2	3	3	2	2	1	1	3	2	1	2	–
CO4	3	3	3	2	2	1	1	3	3	1	2	–

Title of the Course : **FUZZY SETS AND THEIR APPLICATIONS**
Course Code : **MMA26-E301**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Demonstrate the fundamental concepts of crisp and fuzzy sets, including representation, operations, fuzzy convex sets, α-cuts, decomposition theorems, and extension principles in fuzzy set theory.

CO2: Analyze and apply fuzzy operations such as fuzzy complements, t-norms (intersections), t-conorms (unions), and related characteristic theorems and properties in solving fuzzy set problems.

CO3: Apply the concepts of fuzzy numbers, linguistic variables, arithmetic operations on fuzzy numbers, lattice of fuzzy numbers, and fuzzy equations to model uncertainty and approximate reasoning.

CO4: Evaluate crisp and fuzzy relations, fuzzy equivalence relations, max-min composition, transitive closure, fuzzy ranking methods, defuzzification techniques, and formulate solutions to problems in fuzzy linear programming.

UNITS	CONTENTS	L	T	P	Total Hours
1	Crisp sets, Fuzzy sets (basic types), Fuzzy sets (basic concepts), Representation of fuzzy sets, Basic operations on fuzzy sets, Fuzzy convex set, α-cuts, Additional properties of α-cuts, Decomposition Theorems, Extensions principal for fuzzy sets and related theorems.	12	3	-	15
2	Fuzzy Complements, Equilibrium of a fuzzy complement, Theorems on fuzzy complement, Increasing generator, Decreasing generators, Characteristic theorems for fuzzy complement (without proof), Fuzzy intersection (t-norms), Drastic intersection , Characteristic theorem for t-norms (without proof), Theorems on t-norms, Fuzzy Unions (t-conorms), Drastic union, Theorems on t-conorms, Characteristic theorem for t-conorms (without proof), Combinations of operations and related theorems.	14	4	-	18
3	Fuzzy numbers, Linguistic variables, Arithmetic operations on fuzzy numbers, Lattice of fuzzy numbers, Fuzzy equations.	9	2	-	11
4	Crisp and fuzzy relations, Projections, Binary fuzzy relations, Binary relations on a single set, Fuzzy equivalence relations, Max-min composition, Transitive closure of a binary relation, Fuzzy ranking method; Based on Hemming distance, Based on $\boldsymbol{\alpha}$ −cut, Defuzzification; Center of area method, Center of Maxima method, mean of maxima method, Fuzzy linear programming.	13	3	-	16
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. H.J. Zimmerman, Fuzzy Set Theory and Its Applications, Kluwer Academic Publishers
2. G.J. Klier and B. Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India
3. A. Kaufmann and M.M. Gupta, Fuzzy Mathematical Models in Engg. and Mgmt. Sci., Elsevier Sci. Pub.
4. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	3	1	2	1	1
CO2	3	3	3	3	3	3	3	3	1	2	1	1
CO3	3	3	3	3	3	3	3	3	1	2	1	1
CO4	3	3	3	3	3	3	3	2	2	2	1	1

Title of the Course : **MATHEMATICAL STATISTICS**-I
Course Code : **MMA26-E302**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Apply measures of central tendency and variation to analyze and interpret statistical data using mean, median, mode, harmonic mean, geometric mean, quartile deviation, mean deviation, standard deviation and Skewness.

CO2: Understand and solve problems related to probability by applying classical, empirical, and axiomatic approaches, conditional probability, Bayes' theorem, and laws of probability.

CO3: Analyze random variables and probability distributions by evaluating distribution functions, expectation, covariance, variance, moment generating functions, and characteristic functions.

CO4: Apply statistical techniques of curve fitting, correlation, and regression to model data and interpret relationships between variables.

UNITS	CONTENTS	L	T	P	Total Hours
1	Measures of Central Tendency: Arithmetic Mean, Median and Mode, Harmonic Mean and Geometric Mean. Measures of Variation: Quartile deviation, Mean deviation, Standard Deviation, Skewness and Kurtosis.	12	3	-	15
2	Probability: Random Experiment, Sample space and Events, Mathematical or Classical Probability, Statistical or Empirical Probability, Axiomatic Approach to Probability, Probability Function, Law of Addition of Probabilities, Extension of General Law of Addition of Probabilities, Multiplication Law of Probability and Conditional Probability, Extension of Multiplication Law of Probability, Independent Events, Pairwise Independent Events, Probability of Occurrence of At Least One of .the *n* Independent Events, Conditions for Mutual Independence of *n* Events, Bayes Theorem.	12	3	-	15
3	Random Variable, Distribution Function, Properties of Distribution Function, Discrete Random Variable, Probability Mass Function, Discrete Distribution Function, Continuous Random Variable, Probability Density Function, Continuous Distribution Function, Joint Probability Law, Joint Probability Mass Function, Joint Probability Distribution Function, Mathematical Expectation, Expectation of a Function of a Random Variable, Addition Theorem of Expectation, Multiplication Theorem of Expectation, Expectation of a Linear Combination of Random Variables, Covariance, Variance of a Linear Combination of Random Variables, Moment Generating Function, Characteristic Function.	12	3	-	15
4	Curve Fitting: Methods of Least square, Fitting of a Straight .Line, Fitting of a Second Degree Parabola, Change of Origin, Correlation and Regression: Correlation, Karl Pearson Coefficient of Correlation, Limits for Correlation Coefficient, Rank Correlation, Lines of Regression, Regression Coefficients, Properties of Regression Coefficients, Angle between Two Lines of Regression.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. I. Miller and J. E. Freund, Probability and Statistics with Applications, Pearson India.
2. S.C. Gupta and V.K. Kapoor, Probability and Statistics, S. Chand & Sons.
3. M.R. Spiegel, Theory & Problems of Probability, Schaum's Outline Series, McGraw Hill.
4. M. Ray & H.S. Sharma, Mathematical Statistics. Ram Prasad & Sons.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	3	2	3	3	1	3	3	1
CO2	2	3	1	3	3	2	3	3	1	3	3	1
CO3	2	3	2	3	3	3	3	2	1	3	3	1
CO4	2	3	3	3	3	3	3	3	1	3	3	1

Title of the Course : **COMBINATORIAL MATHEMATICS**
Course Code : **MMA26-E303**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand the fundamental principles of counting, permutations, combinations, and combinatorial identities.
CO2: Apply recurrence relations, recursion techniques, and generating functions to solve discrete mathematical problems.
CO3: Analyze sequences, discrete numeric functions, and difference operators in combinatorial structures.
CO4: Evaluate recurrence relations and generating function techniques for solving advanced counting problems.
CO5: Develop mathematical models and problem-solving approaches using combinatorial methods and discrete structures.

UNITS	CONTENTS	L	T	P	Total Hours
1	Fundamental principles of counting, Factorials, Permutations, Circular permutations, Permutations with repetitions, Restricted permutations, Combinations, Restricted combinations, Combinations with repetitions, Combinatorial identities and applications.	12	3	-	15
2	Recurrence relations, Recursive and non-recursive polynomial expressions, Recursion theorem, Iteration, Mathematical induction, Closed form expressions, Sequences and discrete functions, Homogeneous and non-homogeneous recurrence relations, Solutions of recurrence relations, Method of operator.	12	3	-	15
3	Discrete numeric functions, Representation and manipulation of numeric functions, Scalar multiplication and products of numeric functions, Accumulated sums, Forward and backward difference operators, Convolution of numeric functions.	12	3	-	15
4	Generating functions, closed form expressions for generating functions, Properties of generating functions, Applications to recurrence relations, Advanced applications of generating functions, Pigeonhole principle and applications, Problem solving.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. R.A. Brualdi, Introductory Combinatorics, Pearson Education.
2. C.L. Liu, Elements of Discrete Mathematics, McGraw Hill Education.
3. M. Bóna, A Walk Through Combinatorics, World Scientific Publishing
4. K.H. Rosen, Discrete Mathematics and Its Applications, McGraw Hill Education.
5. S.M. Shukla and S.P. Chakravarty, Combinatorics and Graph Theory, Khanna Book Publishing Co.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	1	1	–	–	3	–	2	2	–
CO2	2	3	3	2	1	–	–	2	–	3	2	–
CO3	2	3	3	2	2	–	–	2	–	3	2	1
CO4	2	3	3	2	2	1	–	2	–	3	2	1
CO5	3	3	3	2	3	1	1	2	–	3	2	2

Title of the Course : **ALGEBRAIC NUMBER THEORY**
Course Code : **MMA26-E304**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Define and distinguish between algebraic numbers and algebraic integers using the minimal polynomial.
CO2: Calculate the Norm, Trace, and Discriminant for various number field extensions to determine integral bases.
CO3: Apply the Chinese Remainder Theorem in the context of rings of integers and demonstrate the unique factorization of ideals in Dedekind Domains**.**
CO4: Compute the ideal class group to measure the failure of unique factorization and apply Dirichlet's Unit Theorem to determine the structure of the group of units.

UNITS	CONTENTS	L	T	P	Total Hours
1	Definition of algebraic numbers and algebraic integers, properties of the ring of algebraic integers, Liouville's Theorem on Diophantine approximation and its generalizations, The Chinese Remainder Theorem for general rings and its application to congruences, Introduction to lattices and Minkowski's Convex Body Theorem.	12	3	-	15
2	Definitions and properties of Norm and Trace in finite field extensions, The discriminant of a tuple of elements and the discriminant of a number field, Existence and construction of Integral Bases for quadratic and cyclotomic fields, The sign of the discriminant and its relation to the number of real and complex embeddings.	12	3	-	15
3	Definition and characterization of Dedekind Domains (Noetherian, integrally closed, dimension 1), Fractional ideals and the group of ideals; unique factorization of ideals into prime ideals, The norm of an ideal and its properties, Ramification index, Inertial degree and the fundamental identity.	12	3	-	15
4	The Ideal Class Group and its relation to unique factorization of elements, Finiteness of the class group and the Minkowski Bound for the class number, Structure of the group of units, Roots of unity in number fields, Statement of Dirichlet's Unit Theorem and applications to quadratic and cubic fields.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. I. Stewart and D. Tall, Algebraic Number Theory and Fermat's Last Theorem, A.K. Peters Ltd., Natick Massachusetts.
2. M.R. Murty and J. Esmonde, Problems in Algebraic Number Theory, Springer.
3. W. Stein, Introduction to Algebraic Number Theory, Open-Source, Self-Published Textbook.
4. F. Jarvis, Algebraic Number Theory, Springer.
5. D.A. Marcus, Number Fields, Springer.
6. J. Neukirch, Algebraic Number Theory, Springer.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	-	1	2	2	3	-	-	3	-
CO2	3	3	2	-	2	1	2	3	-	1	3	-
CO3	3	3	3	1	2	2	2	3	-	-	3	-
CO4	3	3	3	1	2	2	2	3	-	-	3	-

Title of the Course : **PYTHON PROGRAMMING**
Course Code : **MMA26-E305**
Nature of the Course : **DSE**
Total Credits : **03**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand the Python environment and apply fundamental syntax, operators and data types to write basic programs.

CO2: Implement decision-making structures and iterative loops to control the flow of a Python program.

CO3: Design and develop reusable code using functions with proper handling of arguments, return values and variable scope.

CO4: Utilize and manipulate built-in data structures including strings, lists, tuples, sets and dictionaries to manage complex data.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction to Programming and Python: Overview of Programming Languages, History and Features of Python, Applications of Python, Installation and Configuration of Python Environment. Python Fundamentals: Python Syntax and Program Structure, Keywords and Identifiers, Comments, Variables, Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Membership Operators, Identity Operators, Operator precedence, Data Types, Input and Output Operations.	11	2	-	15
2	Decision Making and Iterative Statements: if Statement, if–else Statement, Nested if Statement, if–elseif–else Ladder, while Loop, for Loop, break, continue and pass Statements.	10	3	-	13
3	Functions in Python: Functions with and without arguments, Returning values from the functions, Scope of the variables, String creations and operations: String functions, List: List creation and manipulation, Nested Lists, Tuples and Tuple operations, Sets and Dictionaries: Set operations, Dictionary creation and Manipulation.	15	4	-	19
	Total (in Hrs)	36	9	-	45

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. E. Balagurusamy, Introduction to Computing and Problem Solving Using Python, McGraw Hill Education.
2. E. Matthes, Python Crash Course, No Starch Press.
3. A. Sweigart, Automate the Boring Stuff with Python, No Starch Press.
4. A. B. Downey, Think Python: How to Think Like a Computer Scientist, O'Reilly Media.
5. R. N. Rao, Core Python Programming, Dreamtech Press.
6. A.R. Verma, Y. Kumar and S.R. Verma, Basic and Advanced Python Programming Language, Nipa Genx Electronic Resources and Solutions Pvt. Ltd., New Delhi.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	1	2	1	2	-	-	2	1	3
CO2	2	3	3	2	2	1	2	-	1	3	2	3
CO3	2	3	3	3	2	1	2	-	2	3	2	3
CO4	2	3	3	3	2	1	2	-	1	3	2	3

Title of the Course : **LAB COURSE WITH PYTHON**
Course Code : **MMA26-E351**
Nature of the Course : **DSE**
Total Credits : **01**
Distribution of Marks : **30(Ext.) + 20(Int.)**

CO1: Demonstrate the ability to write, debug, and execute Python programs using correct syntax and basic data types.
CO2: Apply arithmetic operators and formulas to solve computational problems.
CO3: Implement conditional statements and loops to manage program flow.
CO4: Develop algorithms to process sequences and series.

CONTENTS	L	T	P	Total Hours
The following practical will be done using the programming language Python and record of those will be maintained in the practical file: **List of Programs:** 1. Program to check whether a number is prime or not. 2. Program to calculate Area of rectangle. 3. Program to accept marks of five subjects and find total marks and percentage assuming full marks as 100 in each subject. 4. Program to swap values of two numbers. 5. Program to perform basic arithmetic operations (addition, subtraction, multiplication, division). 6. Write a program to accept total sales amount and find the profit amount @5%. 7. Write a program to accept electricity unit consumption and calculate total price at the rate of Rs. 5 per unit. Give a discount of 10% on all over bill. 8. Program to generate Fibonacci series up to *n* terms. 9. Program to find maximum between three numbers. 10. Write a program to check whether a given number is positive, negative or zero. 11. Program to count total number of odd and even numbers in the list. 12. Program to find sum of even numbers from 1 to *n*. 13. Write a program to print only even numbers between 1 to *n*. 14. Program to Check whether a number is Armstrong or not. 15. Program to find sum of square of digits of a given number. 16. Write a program to find product of digits of a given number 17. Write a program to reverse a given number. 18. Write a program to check whether a number is palindrome or not. 19. Write a program to print factorial of a given number. 20. Write a program to print table of a given number.	-	-	30	30
Total (in Hrs)	-	-	30	30

MODES OF IN-SEMESTER ASSESSMENT: Practical Tests, Quiz etc.
SUGGESTED READINGS (LATEST EDITION):

1. E. Balagurusamy, Introduction to Computing and Problem Solving Using Python, McGraw Hill Education.
2. E. Matthes, Python Crash Course, No Starch Press.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	3	2	3	-	1	3	3	3
CO2	3	3	3	3	3	2	3	-	2	3	3	3
CO3	3	3	3	3	3	2	3	-	2	3	3	3
CO4	1	3	3	3	3	2	3	-	2	3	3	3

Title of the Course : **ADVANCED NUMERICAL ANALYSIS**
Course Code : **MMA26-C401**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Apply iterative methods to find approximate solutions of linear and non-linear simultaneous equations and obtain eigenvalues of symmetric matrices.

CO2: Describe various methods of interpolation with evenly spaced data and approximation of functions using various orthogonal polynomials.

CO3: Apply various methods to solve ordinary differential equations (IVP and BVP) numerically.

CO4: Obtain numerical solutions of second order linear pde.

UNITS	CONTENTS	L	T	P	Total Hours
1	Solution of system of linear equations: Jacobi's method, Gauss-Seidel method, SOR method, Solutions of Eigenvalues problems: Jacobi's method, Given's method, Householder's method for symmetric matrices, Solution of system of non-linear equations and Solution of complex equation: The method of iteration, Newton-Raphson method.	12	3	-	15
2	Interpolation: Stirling's and Bessel's interpolation, Hermite interpolation, B- spline interpolation, Cubic spline interpolation. Inverse interpolation, Method of successive approximations. Approximation of functions: Legendre polynomials, Chebyshev polynomials.	12	3	-	15
3	Numerical solution of ordinary differential equations: Taylor's series, Picard's successive approximations, Euler's, Modified Euler's, Runge-Kutta and Milne's Predictor-Corrector methods, Simultaneous and higher order equations: Taylor's series and Runge-Kutta methods, Numerical solution of Boundary value problems: Finite differences method.	12	3	-	15
4	Numerical solution of partial differential equations: Classification of second order linear pde, explicit schemes for elliptic, parabolic and hyperbolic pde.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Inc.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, Pvt. Ltd.
3. M.K. Jain, S.R.K Iyengar and R.K.Jain, Numerical methods of Scientific and Engineering Computation, New Age International Pub.
4. R.L. Burden and J.D. Faires, Numerical Analysis, Brooks/Cole Pub Co.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	2	2	3	1	1	3	3	2
CO2	3	3	3	3	2	2	3	1	2	3	3	2
CO3	3	3	3	3	2	2	3	1	3	3	3	2
CO4	3	3	3	3	2	2	3	1	3	3	3	2

Title of the Course : **FOURIER SERIES & WAVELET ANALYSIS**
Course Code : **MMA26-C402**
Nature of the Course : **DSC**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Describe the basics of Fourier series and its convergence.

CO2: Understanding concept of Fourier series, wavelets, continuous wavelet transforms, its basics properties and discrete wavelet transform.

CO3: Learn frame and frame operator ideas for orthogonal wavelets.

CO4: Describe multiresolution analysis, scaling functions and orthonormal wavelet bases, Daubechies wavelets and harmonic wavelets.

UNITS	CONTENTS	L	T	P	Total Hours
1	Fourier Series: Periodic functions, trigonometric series, orthogonal systems, orthogonality of trigonometric systems, Fourier series of 2π-periodic functions with some exercises, Fourier series for orthogonal system, mean square error and its minimum, complete orthonormal system, properties of complete orthonormal systems.	12	3	-	15
2	Wavelet transform: Definitions of wavelets and examples, continuous wavelet transforms and examples, basic properties of wavelet transforms, Parseval's formula for wavelet transform, inversion theorem for wavelet transform. The discrete wavelet transforms and examples, wavelet series and example.	12	3	-	15
3	Frames and MRA: Frames, frame operators, orthonormal wavelets and its examples. Definition of multi-resolution analysis (MRA) and examples, properties of scaling functions and orthonormal wavelets bases, orthonormalization process.	12	3	-	15
4	Construction of Orthonormal Wavelets: Orthonormal Haar wavelets, Daubechies wavelets and algorithms, Riesz spectral factorization, some basic examples of wavelets, harmonic wavelets, orthogonality of harmonic wavelets, normalization of harmonic wavelets.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. G. P. Tolstov, Fourier Series, Dover Pule., INC New York.
2. L. Debnath, Wavelet transforms and Their Applications, Birkhauser, Boston.
3. A. Boggess and F J. Narcowich, A First Course in Wavelets with Fourier Analysis, Prentice Hall.
4. C. K. Chui, An Introduction to Wavelets, Academic Press, New York.
5. E. Herna'ndez and G. Weiss, A First Course in Wavelets, CRC Press, New York.
6. I. Daubechies, Ten Lectures on Wavelets, SIAM Pub.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	1	2	2	2	1	1	-	2
CO2	3	2	3	3	1	2	2	2	2	1	-	2
CO3	2	2	2	2	1	1	2	1	1	2	-	2
CO4	3	3	3	3	1	2	2	1	1	2	-	2

Title of the Course : **MATHEMATICAL STATISTICS-II**
Course Code : **MMA26-E401**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Apply the concepts of probability distributions including Bernoulli, Binomial, Poisson, Normal, Uniform, and Exponential distributions, and compute their measures such as mean, variance, and moments up to fourth order.

CO2: Demonstrate understanding of sampling methods and formulate statistical hypotheses by applying concepts of level of significance, critical region, one-tailed and two-tailed tests, and significance testing for large and small samples.

CO3: Analyze and interpret statistical data using Chi-square and Student's t-distributions for testing population variance, goodness of fit, population mean, and comparison between two means including paired t-test.

CO4: Evaluate and apply different estimation techniques including point and interval estimation, maximum likelihood method, method of moments, and properties of estimators such as unbiasedness, efficiency, consistency, and sufficiency.

UNITS	CONTENTS	L	T	P	Total Hours
1	Bernoulli's Distribution, Binomial Distribution, Poisson distribution (their density functions, mean, variance, moments up to fourth order), Normal Distribution, Uniform & Exponential distribution.	12	3	-	15
2	Sampling, types of Sampling, Test the significance, critical region and level of significance, Null hypothesis, Test of hypothesis, Critical Region and Level of Significance, One Tailed and Two Tailed Tests, Critical or Significant Values, Procedure for Testing of Hypothesis, Large Sample and small samples, Test of Significance for Large Samples; Testing the significance of sample mean and difference between means of two samples.	12	3	-	15
3	Chi square distribution: Test based on Chi-square distribution, Test for significance for population variance, Testing the goodness of fit, Student's t-distribution (t-statistic), t-distribution, degree of freedom, Test based on t-distribution; Testing of significance of population mean, testin the significance of the difference between two means (paired t-test).	12	3	-	15
4	Pt. Estimation, Interval Estimation, Methods of Estimation, Max Likelihood method, Method of moments, Unbiasedness, Efficiency, Consistency, Sufficiency.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. I. Miller and J. E. Freund, Probability and Statistics with Applications, Pearson India.
2. S.C. Gupta and V.K. Kapoor, Probability and Statistics, S. Chand & Sons.
3. M.R. Spiegel, Theory and Problems of Probability, Schaum's Outline Series, McGraw Hill.
4. M. Ray and H.S. Sharma, Mathematical Statistics. Ram Prasad & Sons.
5. R. E. Walpole, R. H. Myers, S. L. Myers and K. E. Ye, Probability and Statistics for Engineers and Scientists, Pearson Pub.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	3	2	3	3	1	3	3	1
CO2	2	3	1	3	3	2	3	3	1	3	3	1
CO3	2	3	2	3	3	3	3	2	1	3	3	1
CO4	2	3	3	3	3	3	3	3	1	3	3	1

Title of the Course : **FRACTIONAL CALCULUS**
Course Code : **MMA26-E402**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Discuss some special functions and transform with counter examples.
CO2: Provide Fractional derivatives and integrals with examples.
CO3: Explain Transform of fractional derivatives with some applications.
CO4: Discuss applications in fields of physical and mathematical sciences.

UNITS	CONTENTS	L	T	P	Total Hours
1	Functions: Definition of the Gamma and Beta functions, some properties of its, relation between Gamma and Beta functions. Special Function: Definition of Mittag-Leffler functions of one and two parameters, relations of Mittag-Leffler function to some other functions, The Laplace transform of Mittag-Leffler function in two parameters. Wright function, definition of Wright function.	12	3	-	15
2	Fractional Derivatives and Integrals: Left and right fractional derivatives. Grunwald-Letnikov fractional derivatives, Riemann-Liouville fractional derivatives, Caputo's fractional derivative, fractional derivatives of standard functions and their graphical representation, fractional integrals.	12	3	-	15
3	Transform of Fractional Derivatives: Geometric and physical interpretation of fractional integral and fractional differentiations. Laplace transform of fractional derivatives, Fourier transform of fractional derivatives.	12	3	-	15
4	Applications: Linear fractional differential equations (homogeneous fractional differential equations and non-homogeneous fractional differential equations), existence and uniqueness theorem as a method of solution, Laplace transform method to solve fractional differential equations.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. I. Podlubny, Fractional Differential Equations, Academic press, Boston, New York.
2. K. S. Miller and B. Ross, An Introduction to Fractional Calculus and Fractional Differential Equations, John Wiley, New York.
3. K. B. Oldham and J. Spanier, The Fractional Calculus, Academic press, New York.
4. A.K. Anatoly, H.M. Shrivastav and J.J. Trujillo, Theory and Applications of Fractional Differential Equations, Elesevier, New York.
5. S. Das, Functional Fractional Calculus, Springer-Verlag, Berlin Heidelberg.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	3	2	3	1	2	2	2	2	1	-	1
CO2	2	2	3	3	1	2	2	2	2	1	-	1
CO3	2	2	2	2	1	1	3	1	2	2	-	1
CO4	3	3	2	2	1	2	3	1	2	2	-	2

Title of the Course : FINANCIAL MATHEMATICS
Course Code : MMA26-E403
Nature of the Course : DSE
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Understand the fundamental concepts of financial markets, derivative securities, and the functioning of futures and options markets.

CO2: Apply principles of option pricing and hedging techniques, and analyze the structure and applications of interest rate swaps.

CO3: Explain the no-arbitrage pricing framework and distinguish between various types of options and their characteristics.

CO4: Understand and apply option hedging parameters (Greeks), Delta, Gamma, Theta, Vega, and Rho, to measure risk sensitivities and implement Delta and Gamma hedging strategies for managing derivative portfolios.

UNITS	CONTENTS	L	T	P	Total Hours
1	Interest Rates and Their Types, Measurement of Interest Rates, Zero Rates and Forward Rates, Bond Pricing, Duration, and Convexity, Exchange-Traded and Over-the-Counter (OTC) Markets, Introduction to Derivatives, Forward Contracts, Futures Contracts, and Options, Types of Traders and Their Roles,Hedging, Speculation, and Arbitrage Strategies.	12	3		15
2	No Arbitrage principle, short selling, Forward price for an investment asset, Types of options, Option positions, Underlying assets, Factors affecting option prices.	12	3		15
3	Bounds on option prices, Put-call parity, Early exercise, Trading strategies involving options, Effect of dividends. Binomial option pricing model.	12	3		15
4	Brownian motion (Wiener Process), Geometric Brownian Motion (GBM), Distribution of the rate of return, Expected return, Volatility, Estimating volatility from historical data. Hedging parameters - The Greek letters: Delta, Gamma, Theta, Rho and Vega; Delta hedging, Gamma hedging.	12	3		15
	Total (in Hrs)	**48**	**12**		**60**

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. J. C. Hull, & S. Basu, Options, Futures and Other Derivatives, Pearson Education. New Delhi.
2. G. David, Investment Science, Oxford University Press, Delhi.
3. S. Benninga and T. Mofkadi, Financial Modeling, MIT Press, Massachusetts.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	3	1	1	2	2	2	1	2	1
CO2	3	3	2	3	2	1	2	1	3	3	2	2
CO3	3	3	3	2	2	1	2	2	2	2	3	1
CO4	3	3	3	3	2	1	2	1	3	3	2	2

Title of the Course : **SOFT COMPUTING**
Course Code : **MMA26-E404**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Explain the fundamental concepts of Soft Computing, distinguish between soft and hard computing approaches, and describe the transition from conventional Artificial Intelligence to Computational Intelligence.

CO2: Apply fuzzy set theory concepts, including fuzzy sets, α-cuts, fuzzy relations, linguistic variables, membership functions, fuzzification, defuzzification, fuzzy ranking methods, and fuzzy inference systems to model uncertainty and imprecision.

CO3: Analyze and implement Genetic Algorithms by employing encoding schemes, fitness functions, selection, crossover, mutation operators, and optimization cycles for solving complex computational problems.

CO4: Demonstrate understanding of Neural Network architectures and learning paradigms, including single-layer and multilayer networks, back propagation, radial basis function networks, unsupervised learning, reinforcement learning, and their real-world applications.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction to Soft Computing: Introduction, Soft Computing vs Hard computing, Soft computing characteristics, Constituents of soft computing, From conventional AI to Computational Intelligence. Fuzzy Set theory: Fuzzy Sets & Classical Sets; Operations on Fuzzy Sets.	12	3	-	15
2	α-cuts, Additional properties of α-cuts, Fuzzy Relations, Linguistic Variables, Membership Functions & Fuzzification, Methods of Membership Value Assignment, Defuzzification. Fuzzy ranking methods, Fuzzy Inference Systems.	12	3	-	15
3	Genetic algorithm: Fundamental, basic concepts, working principle, encoding, fitness function, Basic Operators for Genetic Algorithms, Crossover and Mutation Properties, Genetic Algorithm Cycle, Fitness Function, Applications of Genetic Algorithm.	12	3	-	15
4	Neural Network: Introduction to Neural Networks, Types of learning, Neural network architectures, Single layer networks, Multilayer networks with back propagation learning, Radial basis function Networks, Unsupervised learning with Neural Networks, Advances in Neural Networks, Applications of neural networks, Overview of Reinforcement Learning.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. S. Roy and U. Chakraborty, Introduction to Soft Computing, Pearson Education India.
2. G. J. Klier and B. Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India.
3. D. E. Goldberg, Genetic Algorithms-In Search, optimization and Machine learning, Pearson Education.
4. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, Wiley India.
5. M. Mitchell, An Introduction to Genetic Algorithm, PHI.
6. N. K. Kasabov, Foundations of Neural Networks, Fuzzy Systems and Knowledge Engineering, MIT Press.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3	3	3	2	1	2	1	2
CO2	3	3	3	3	3	2	3	1	1	2	1	2
CO3	3	2	3	3	3	3	3	2	2	2	1	3
CO4	3	3	3	3	3	2	3	2	1	3	1	2

Title of the Course : **GRAPH THEORY**
Course Code : **MMA26-E405**
Nature of the Course : **DSE**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Analyze the structural properties of graphs including connectivity, paths, circuits, Eulerian and Hamiltonian graphs, and graph isomorphisms.

CO2: Apply concepts of cut-sets, connectivity, separability, planarity, and graph duality to solve theoretical and practical graph problems.

CO3: Utilize graph matrices, vector spaces associated with graphs, trees, spanning trees, and weighted graphs in mathematical modeling and network analysis.

CO4: Evaluate relations and directed graphs using equivalence relations, transitive closure, and Warshall's algorithm for discrete structures and computational applications.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction, Finite and infinite graphs, incidence and degree, isomorphism, subgraphs Walks, Paths and Circuits, Connected and Disconnected graphs, Components, Euler graph, Unicursal graph, Operations on graphs, Hamiltonian paths and circuits, Traveling Salesman Problem, Konigsberg Bridge Problem, Chinese postman Problem Directed graphs, Types of digraphs, shortest path problem, Dijkastra's Algorithm.	12	3	-	15
2	Cuts-sets and Cut-vertices, properties of a Cut-set, All Cut-Sets in a graph, Fundamental circuits and cut-sets, Connectivity and Separability, Isomorphism, 1- Isomorphism, 2- Isomorphism, Combinatorial vs. Geometric graphs, Planar graphs, Kuratowski's two graphs, Detection of planarity, Geometric Dual, Combinatorial Dual.	12	3	-	15
3	Modular arithmetic, Vector space associated with a graph, Incidence matrix, Submatrix of A(G), Circuit matrix, Fundamental circuit matrix and rank of B, Cut-set matrix, Path matrix and Adjacency matrix.	12	3	-	15
4	Trees, Properties of Trees, Distance and Centres in a tree, Rooted and binary tress Counting trees, Spanning trees, Fundamental circuits, Spanning trees of a graph and weighted graph, Kruskals Algirithm, Prim's Algorithm. Relations and digraphs: Product Sets and Partitions, Paths in Relations and Digraphs, Properties of Relations, Equivalence Relations, Computer Representation of Relations and Digraphs, Transitive Closure, Warshall's Algorithm.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, Elsevier.
2. D.B. West, Introduction to Graph Theory, Pearson Education.
3. F. Harary, Graph Theory, Narosa Publishing House.
4. K. H. Rosen, Discrete Mathematics and Its Applications, McGraw Hill Education.
5. G. Chartrand and L. Lesniak, Graphs and Digraphs, CRC Press.
6. R. J. Wilson, Introduction to Graph Theory, Pearson Education.
7. N. Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall India.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	1	1	–	–	3	–	2	2	–
CO2	3	3	3	2	1	–	–	3	–	2	2	–
CO3	3	3	3	2	2	–	–	2	1	3	2	1
CO4	2	3	3	3	2	1	–	2	–	3	2	2

Title of the Course : QUANTUM COMPUTING
Course Code : MMA26-E406
Nature of the Course : DSE
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Analyze the mathematical structure of qubits and state spaces using Kronecker products and matrix properties.
CO2: Evaluate the evolution of quantum systems through density operators and unitary transformations.
CO3: Synthesize quantum algorithms and measurement protocols to solve computational problems.
CO4: Apply the theory of infinite-dimensional Hilbert spaces, including coherent and squeezed states, to quantum optical systems.

UNITS	CONTENTS	L	T	P	Total Hours
1	Definition of a qubit, state vectors, superposition, and the Bloch sphere representation, Mathematical properties of Kronecker products, construction of multi-qubit systems, and product Hilbert spaces, Hermitian, unitary, and normal matrices; eigenvalues and eigenvectors, Spectral decomposition theorem.	12	3	-	15
2	Pure vs. mixed states, properties of the density matrix, and state preparation, Computing reduced density matrices and the mathematical description of subsystems, Reversible classical computing and the mapping of bits to qubits.	12	3	-	15
3	Pauli gates, Hadamard, CNOT, and Toffoli gates; universal sets of quantum gates, Projection-valued measures (PVM), Positive Operator-Valued Measures (POVM), and measurement outcomes, Mathematical structure of basic algorithms like Deutsch-Jozsa or Grover's search.	12	3	-	15
4	The bit-flip and phase-flip codes, Shor's nine-qubit code foundations, Creation and annihilation operators in infinite-dimensional Hilbert spaces, Displacement operators, Uncertainty relations and the mathematical properties of non-classical light states.	12	3	-	15
	Total (in Hrs)	48	12	-	60

MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS (LATEST EDITION):

1. M.A. Nielsen and I.L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press.
2. W.H. Steeb and Y. Hardy, Problems and Solutions in Quantum Computing and Quantum Information, World Scientific Publishing Co. Pvt. Ltd., Singapore.
3. J.M. Landsberg, Quantum Computation and Quantum Information: A Mathematical Perspective, American Mathematical Society.
4. E.G. Rieffel and W.H. Polak, Quantum Computing: A Gentle Introduction, The MIT Press.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	2	2	1	2	3	-	1	3	1
CO2	3	3	3	3	2	1	2	3	2	-	3	2
CO3	3	3	3	3	3	2	3	2	-	3	3	3
CO4	3	3	2	3	3	1	2	3	3	-	3	2

Title of the Course : **LAB BASED COURSE-1**
Course Code : **MMA26-H161**
Nature of the Course : **HL**
Total Credits : **02**
Distribution of Marks : **30(Ext.) + 20(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to

CO1: Create and compile basic LaTeX documents using proper command structures, environments, and special character handling.

CO2: Structure professional documents by configuring document classes, page styles, and automated organizational elements like tables of contents.

CO3: Design complex page layouts by implementing font variations, advanced list structures, and precise table formatting using boxes and alignments.

CO4: Typeset sophisticated mathematical content by effectively utilizing math environments, symbols, and specialized notation elements.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction, Basics of a Latex file. Text, Symbols and Commands: Command names and arguments, environments, Declarations, Lengths, Special characters.	-	-	15	15
2	Document Layout and Organization: Document class, Page style, Parts of the document, Table of contents.	-	-	15	15
3	Displayed Text: Changing font style, Centering and indenting, Lists, Generalized lists, Tabular stops, Boxes, Tables.	-	-	15	15
4	Mathematical Formulas: Mathematical Environment, Main elements of math mode, Mathematical symbols, Additional Elements.	-	-	15	15
	Total (in Hrs)	-	-	60	60

MODES OF IN-SEMESTER ASSESSMENT: Practical Tests, Quiz etc.

SUGGESTED READINGS (LATEST EDITION):

1. L. Lamport, LaTeX: A Document Preparation System, 2nd Edition, Addison-Wesley.
2. H. Kopka and P.W. Daly, Guide to LaTeX, Fourth Edition, Addison-Wesley, Pearson Education.
3. F. Mittelbach et al., The LaTeX Companion, 2nd Edition, Addison-Wesley.
4. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	2	1	3	3	2	-	-	-	1	3
CO2	1	2	2	2	3	3	2	-	-	-	1	3
CO3	1	2	2	2	3	3	2	-	-	-	1	3
CO4	3	3	3	2	3	3	2	2	2	1	2	3

Title of the Course : **LAB BASED COURSE-2**
Course Code : **MMA26-H261**
Nature of the Course : **HL**
Total Credits : **02**
Distribution of Marks : **30(Ext.) + 20(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Perform basic symbolic computations, manipulate algebraic equations through simplification and expansion and solve mathematical equations using MAXIMA.
CO2: Compute calculus operations and series expansions.
CO3: Execute linear algebra and matrix operations.
CO4: Construct 2D and 3D visual representations to analyze mathematical data visually.

CONTENTS	L	T	P	Total Hours
Introduction & Basic Operations, Symbolic Computation and Algebra: Simplification & Expansion, Equation Solving, Calculus and Series: Limits & Continuity, Differentiation & Integration, Series Expansion. Linear Algebra: Matrix Manipulations, System of Equations, Graphics and Plotting: 2D Graph Plotting and 3D surface plotting. The following practicals will be done using MAXIMA software and their record will be maintained in the practical file: 1. Learn to use basic operators and functions in Maxima software. 2. Simplify algebraic expressions and expressions containing radicals, logarithms, exponentials and trigonometric functions. 3. Evaluate limits of functions as x $\longrightarrow$ c. 4. Find derivatives of algebraic, trigonometric, exponential and logarithmic functions. 5. Find derivatives of functions involving above mentioned functions. 6. Solve Problems of successive differentiation. 7. Find indefinite integrals of different functions. 8. Find definite integrals of different functions. 9. Expand algebraic, rational, trigonometric and logarithmic expressions. 10. Learn to use matrix operations (addition, subtraction, multiplication). 11. Learn to find determinant, inverse, and rank of a matrix. 12. Learn to find eigenvalues and eigenvectors of a matrix. 13. Solve systems of linear equations using matrices. 14. To plot curves involving Cartesian, parametric and polar forms. 15. To demonstrate singular points.	-	-	60	60
Total (in Hrs)	-	-	60	60

MODES OF IN-SEMESTER ASSESSMENT: Practical Tests, Quiz etc.

SUGGESTED READINGS:

1. Kalyanrao Takale, Shrikisan Gailwad, Amjad Shaikh, Veena Kshirsagar and S. R. Patil, computational mathematics using maxima software, Nirali Prakashan.
2. Maxima, a Computer Algebra System, https://maxima.sourceforge.io › docs › maximabook
3. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	3	2	3	-	1	3	3	3
CO2	3	3	3	3	3	2	3	-	2	3	3	3
CO3	3	3	3	3	3	2	3	-	2	3	3	3
CO4	1	3	3	3	3	2	3	-	2	3	3	3

Title of the Course : **LAB BASED COURSE-3**
Course Code : **MMA26-H461**
Nature of the Course : **HL**
Total Credits : **02**
Distribution of Marks : **30(Ext.) + 20(Int.)**

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Understand the basics of R programming language including data types, variables, operators, expressions.
CO2: Understand and implement control structures and functions.
CO3: Utilize built in functions and tools of general use in R.
CO4: Learn entering, plotting, manipulation and interpretation of data using statistical functions of R.

CONTENTS	L	T	P	Total Hours
Introduction, Arithmetic and Logical Operators, Functions, variables and data types in R, Numeric, Character and Logical Data, Vectors, Matrices and arrays, Lists, Data Frames, Factors, Tables. Control structures, functions, scoping rules, Math Functions, Calculating a Probability, Cumulative Sums and Products, Minima and Maxima, Functions for Statistical Distributions. Data Visualization using R: Scatter Plots, Box Plots, Scatter Plots and Box and Whisker Plots Together, Customize plot axes, labels, add legends, and add colours. The following practicals will be done on the R platform/software package and record of those will be maintained in the practical file: 1. Starting R, entering data, storing data as a vector. 2. Entering data into R; i. Using c ii. Using scan iii. Using scan with file iv. Editing your data v. Reading in tables of data vi. Spreadsheet data 3. Practical examples illustrating templates of functions, for loops and conditional expressions in R. 4. Find mean, variance and standard deviation using R functions. 5. Practical examples with univariate data: i. Categorical data; Using tables, factors, bar chart, pie chart ii. Numerical data; measures of center and spread iii. Stems and leaf charts, histograms, boxplots, frequency polygons using R functions 6. Comparison of bivariate data with plots. 7. Program to fit linear regression line. 8. Program to find Spearman's rank correlation coefficient. 9. Practical examples of plotting graphs using points, abline, lines, plot and curve R functions. 10. Practical examples of storing, accessing and manipulating multivariate data in data frames. 11. Generate random numbers using uniform, normal, binomial, exponential distributions. 12. To estimate confidence interval using p-test. 13. To estimate confidence interval using t-test. 14. To estimate confidence interval using z-test. 15. Hypothesis testing by mean and median.	-	-	60	60
Total (in Hrs)	-	-	60	60

MODES OF IN-SEMESTER ASSESSMENT: Practical Tests, Quiz etc.

SUGGESTED READINGS (LATEST EDITION):

1. R. D. Peng, R Programming for Data Science.
2. N. Matloff, The Art of R Programming- A Tour of Statistical Software Design.
3. J. Verzani, Using R for Introductory Statistics, Chapman and Hall/CRC.
4. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	3	2	3	2	3	-	1	3	3	3
CO2	3	3	3	3	3	2	3	-	2	3	3	3
CO3	3	3	3	3	3	2	3	-	2	3	3	3
CO4	1	3	3	3	3	2	3	-	2	3	3	3