Curriculum Structure for Four-Year Under Graduate Programme with Multiple Entry and Exit Option

Program: B.Sc. Mathematics (Honors / Honors with Research)

Mathematics as a MAJOR with another subject as a MINOR

(Effective from Session 2025-26)

(The revised syllabus Sem. III onwards will also be implemented for the students admitted in session 2024-25)

Semester	Course Code and Name	L	T	P	Credits
I	BMA24-MJ101 **(CALCULUS)**	**45**	**15**	**-**	4
	Vocational Course-1 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	Multi-Disciplinary Generic Elective Course-1 **(TO BE OPTED FROM OTHER DEPARTMENT)**				3
	Ability Enhancement Course-1 (**ENGLISH)**				4
	Value Added Course-1 **(DIGITAL AND TECHNOLOGICAL SOLUTIONS)**				2
	Value Added Course-2 **(PROFESSIONAL ETHICS AND GENDER STUDIES)**				2
	Skill Enhancement Course-1 **(TO BE OPTED FROM OTHER DEPARTMENT)**				3
	Total				**22**
II	BMA24-MJ201 **(ADVANCED CALCULUS)**	**45**	**15**	**-**	4
	Vocational Course-2 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	Multi-Disciplinary Generic Elective Course-2 **(TO BE OPTED FROM OTHER DEPARTMENT)**				3
	Ability Enhancement Course-2 **(HINDI / SANSKRIT)**				4
	Value Added Course-3 **(UNDERSTANDING INDIA)**				2
	Value Added Course-4 **(ENVIRONMENT SCIENCE)**				2
	Skill Enhancement Course-2 **(TO BE OPTED FROM OTHER DEPARTMENT)**				3
	Total				**22**
Grand Total (Semester I and II)					**44**

NOTE: The students on exit shall be awarded an **Undergraduate Certificate (in Mathematics)** after securing the requisite **44 Credits on completion of semester II**, provided they complete **one vocational course of 4 credits** (as part of the minor) or complete an **Internship / Apprenticeship within one year from the completion of the Second semester examination.**

Semester	Course Code and Name	L	T	P	Credits
III	BMA24-MJ301 **(ORDINARY DIFFERENTIAL EQUATIONS)**	**45**	**15**	**-**	4
	BMA24-MJ302 **(ALGEBRA)**	**45**	**15**	**-**	4
	Vocational Course-3 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	Multi-Disciplinary Generic Elective Course-3 **(TO BE OPTED FROM OTHER DEPARTMENT)**				3
	Value Added Course-5 **(HEALTH & WELLNESS, YOGA EDUCATION, SPORTS & FITNESS)**				2
	Value Added Course-6 **(PANCHMAHAYAJNA)**				2
	Skill Enhancement Course-3 **(SOFT SKILLS)**				3
	Total				**22**
IV	BMA24-MJ401 **(REAL ANALYSIS)**	**45**	**15**	**-**	4
	BMA24-MJ402 **(PARTIAL DIFFERENTIAL EQUATIONS)**	**45**	**15**	**-**	4
	BMA24-MJ403 **(NUMBER THEORY)**	**45**	**15**	**-**	4
	BMA24-MJ404 **(MOOC / ONLINE COURSE-1)**	**45**	**15**	**-**	4
	Minor Course-1 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	Community engagement **(NCC / NSS / Adult Education / Student Mentoring / NGO / Govt. Institutions, etc.) / Internship**				2
	Total				**22**
Grand Total (Semester I , II, III and IV)					**88**

NOTE: The students on exit shall be awarded an **Undergraduate Certificate (in Mathematics)** after securing the requisite **88 Credits on completion of semester IV**, provided they complete **one additional vocational course of 4 credits** (as part of the minor) or complete an **Internship / Apprenticeship within one year from the completion of the Fourth semester examination.**

Semester	Course Code and Name	L	T	P	Credits
V	BMA24-MJ501 **(LINEAR PROGRAMMING)**	**45**	**15**	**-**	4
	BMA24-MJ502 **(VECTOR AND TENSOR CALCULUS)**	**45**	**15**	**-**	4
	BMA24-MJ503 **(LINEAR ALGEBRA)**	**45**	**15**	**-**	4
	BMA24-MJ504 **(MECHANICS)**	**45**	**15**	**-**	4
	Minor Course-2 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	Internship				2
	Total				**22**
VI	BMA24-MJ601 **(ANALYTICAL GEOMETRY)**	**45**	**15**	**-**	4
	BMA24-MJ602 **(MATHEMATICAL MODELLING)**	**45**	**15**	**-**	4
	BMA24-MJ603 **(NUMERICAL ANALYSIS)**	**45**	**15**	**-**	4
	BMA24-MJ604 **(MOOC / ONLINE COURSE-2)**	**45**	**15**	**-**	4
	Minor Course-3 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	BMA24-PR601 **(PROJECT)** **OR** Any one of following: BMA24-MJ605 (**RESEARCH ETHICS)** BMA24-MJ606 **(FLUID DYNAMICS)** BMA24-MJ607 **(DIFFERENTIAL GEOMETRY)** BMA24-MJ608 **(SPECIAL FUNCTIONS)**				2
	Total				**22**
Grand Total (Semester I , II, III, IV, V and VI)					**132**

NOTE: The students on exit shall be awarded **Bachelor of Science in Mathematics** after securing the requisite **132 Credits on completion of semester VI** .

Semester	Course Code and Name	L	T	P	Credits
VII	BMA24-MJ701 **(ADVANCED REAL ANALYSIS)**	**45**	**15**	**-**	4
	BMA24-MJ702 **(MATHEMATICAL STATISTICS)**	**45**	**15**	**-**	4
	BMA24-MJ703 **(ABSTRACT ALGEBRA)**	**45**	**15**	**-**	4
	BMA24-PR701 **(RESEARCH PROJECT)** **OR** Any two of the following: BMA24-MJ704 **(ANCIENT INDIAN AND VEDIC MATHEMATICS)** BMA24-MJ705 **(GRAPH THEORY)** BMA24-MJ706 **(FRACTIONAL CALCULUS)** BMA24-MJ707 **(CRYPTOGRAPHIC MATHEMATICS)**	**45**	**15**	**-**	6 3x2=6
	Minor Course-4 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	Total				**22**
VIII	BMA24-MJ801 **(TOPOLOGY)**	**45**	**15**	**-**	4
	BMA24-MJ802 **(COMPLEX ANALYSIS)**	**45**	**15**	**-**	4
	BMA24-MJ803 **(OPTIMIZATION TECHNIQUES)**	**45**	**15**	**-**	4
	BMA24-MJ804 **(DISSERTATION)**				6
	Minor Course-5 **(TO BE OPTED FROM OTHER DEPARTMENT)**				4
	Total				**22**
Grand Total (Semester I , II, III, IV, V, VI, VII and VIII)					**176**

NOTE: The students on exit shall be awarded **Bachelor of Science in Mathematics(Honors or Honors with Research)** after securing the requisite **176 Credits on completion of semester VIII** .

Mathematics as a MINOR with another subject as a MAJOR

(Effective from Session 2024-2025)

Semester	Course Code and Name	L	T	P	Credits
I	Major-1 **(Another Subject)**				4
	Vocational Course-1	**45**	**15**	**-**	4
	Multi-Disciplinary Generic Elective Course-1 BMA24-MD101 (**BASIC MATHEMATICS**)*	**34**	**11**	**-**	3
	Ability Enhancement Course-1 (**ENGLISH)**				4
	Value Added Course-1 **(DIGITAL AND TECHNOLOGICAL SOLUTIONS)**				2
	Value Added Course-2 **(PROFESSIONAL ETHICS AND GENDER STUDIES)**				2
	Skill Enhancement Course-1	**34**	**11**		3
	Total				**22**
II	Major-2 **(Another Subject)**				4
	Vocational Course-2	**45**	**15**	**-**	4
	Multi-Disciplinary Generic Elective Course-2 BMA24-MD201 **(BASIC PROBABILITY AND STATISTICS)***	**34**	**11**	**-**	3
	Ability Enhancement Course-2 **(HINDI / SANSKRIT)**				4
	Value Added Course-3 **(UNDERSTANDING INDIA)**				2
	Value Added Course-4 **(ENVIRONMENT SCIENCE)**				2
	Skill Enhancement Course-2	**34**	**11**	**-**	3
	Total				**22**
Grand Total (Semester I and II)					**44**

NOTE: The students on exit shall be awarded an **Undergraduate Certificate (in Mathematics)** after securing the requisite **44 Credits on completion of semester II**, provided they complete **one vocational course of 4 credits** (as part of the minor) or complete an **Internship / Apprenticeship within one year from the completion of the Second semester examination.**

Semester	Course Code and Name	L	T	P	Credits
III	Major-3 **(Another Subject)**				4
	Major-4 **(Another Subject)**				4
	Vocational Course-3	**45**	**15**	**-**	4
	Multi-Disciplinary Generic Elective Course-3 BMA24-MD301 (**BASIC MATHEMATICAL MODELLING**)*	**34**	**11**	**-**	3
	Value Added Course-5 **(HEALTH & WELLNESS, YOGA EDUCATION, SPORTS & FITNESS)**				2
	Value Added Course-6 **(PANCHMAHAYAJNA)**				2
	Skill Enhancement Course-3				3
	Total				**22**
IV	Major-5 **(Another Subject)**				4
	Major-6 **(Another Subject)**				4
	Major-7 **(Another Subject)**				4
	Major-8 **(Another Subject)**				4
	BMA24-MI401 **(DIFFERENTIAL EQUATIONS)***	**45**	**15**	**-**	4
	Community engagement **(NCC / NSS / Adult Education / Student Mentoring / NGO / Govt. Institutions, etc.) / Internship**				2
	Total				**22**
Grand Total (Semester I , II, III and IV)					**88**

NOTE: The students on exit shall be awarded an **Undergraduate Certificate (in Mathematics)** after securing the requisite **88 Credits on completion of semester IV**, provided they complete **one additional vocational course of 4 credits** (as part of the minor) or complete an **Internship / Apprenticeship within one year from the completion of the Fourth semester examination.**

Semester	Course Code and Name	L	T	P	Credits
V	Major-9 **(Another Subject)**				4
	Major-10 **(Another Subject)**				4
	Major-11 **(Another Subject)**				4
	Major-12 **(Another Subject)**				4
	BMA24-MI501 **(LINEAR ALGEBRA)***	**45**	**15**	**-**	4
	Internship				2
	Total				**22**
VI	Major-13 **(Another Subject)**				4
	Major-14 **(Another Subject))**				4
	Major-15 **(Another Subject)**				4
	Major-16 **(Another Subject)**				4
	BMA24-MI601 **(NUMERICAL ANALYSIS)***	**45**	**15**	**-**	4
	Project **or Any one DSE**				2
	Total				**22**
Grand Total (Semester I , II, III, IV, V and VI)					**132**

NOTE: The students on exit shall be awarded **Bachelor of Science in Mathematics** after securing the requisite **132 Credits on completion of semester VI** .

Semester	Course Code and Name	L	T	P	Credits
VII	Major-17 **(Another Subject)**				4
	Major-18 **(Another Subject)**				4
	Major-19 **(Another Subject)**				4
	BMA24-MI701 **(MATHEMATICAL STATISTICS)***	**45**	**15**	**-**	4
	Research Project **or Any two DSE**				6
	Total				**22**
VIII	Major-20 **(Another Subject)**				4
	Major-21 **(Another Subject)**				4
	Major-22 **(Another Subject)**				4
	Dissertation **(Another Subject)**				6
	BMA24-MI801 **(OPTIMIZATION TECHNIQUES)***	**45**	**15**	**-**	4
	Total				**22**
Grand Total (Semester I , II, III, IV, V, VI, VII and VIII)					**176**

NOTE: The students on exit shall be awarded **Bachelor of Science in Mathematics(Honors or Honors with Research)** after securing the requisite **176 Credits on completion of semester VIII** .

Annexure-II: Semester-wise Distribution of Credits

Semester	Major (Core)	Minor	Multi-Disciplinary Generic Elective course	Ability Enhancement Course (AEC)	Value Added Course (VAC)	Skill Enhancement Course (SEC)	Others	Total Credit	Exit Option (With Certificate /Diploma and Degree)
I	4	4	3	4	2 x 2=4	3	--	22	UG Certificate 44
II	4	4	3	4	2 x 2=4	3	--	22	
III	4 x 2=8	4	3	2	2	3	--	22	UG Diploma 88
IV	4 x 4=16	4	--	--	--	--		22	
V	4 x 4=16	4	--	--	--	--	2(Internship)	22	Three Year UG 132
VI	4 x 4=16	4	--	--	--	--	2(Project)/2 x1 (DSE)	22	
VII	4 x 3=12	4	--	--	--	--	6 (Research Methodology and Project)/ 3x2=6(DSE)	22	Four Year UG (Honors / (Honors with Research) 176
VIII	4 x 3=12	4	--	--	--	--	6(Dissertation)	22	
Total	88	32	9	10	10	9	18	176	

Programme Outcome/ Programme Specific Outcome
Programme Outcome: After completing the Four-Year B.Sc. Mathematics (Hons/Hons with research) Degree programme the students will be able to - PO1: Inculcate foundation knowledge to understand basics of mathematics including applied aspect for the same. PO2: Evolve in-depth knowledge of various branches of pure and applied mathematics. PO3: Enhance the ability to develop solution-oriented approach towards various real world problems. PO4: Develop scientific and mathematical temper. **Programme Specific Outcome:** After completing the Four-Year B.Sc. Mathematics (Hons/Hons with research) Degree programme the students will be able to- PSO1: Formulate and develop mathematical arguments in a logical manner. PSO2: Apply their skills and knowledge in various fields of studies including, science, engineering, commerce and management etc.

Title of the Course : **CALCULUS**
Course Code : **BMA24-MJ101**
Nature of the Course : **Major**
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 basics of limit, continuity and successive differentiation.
CO2: Explain partial differentiation, total differentiation and expansion of functions.
CO3: Understand the basic concepts of Jacobian and maxima, minima upto two independent variables.
CO4: Understand the basics of tangents and normal, asymptotes and curve tracing.

UNITS	CONTENTS	L	T	P	Total Hours
1	Limit and continuity (ε-δ definition), basic properties of limits and classification of discontinuities, differentiability, successive differentiation, Leibnitz theorem, Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem.	10	3	-	13
2	Expansion of Function: Maclaurin series expansion, Taylor theorem, Taylor Series of two variables, Partial differentiation, Homogeneous function, Euler's theorem on homogeneous function, Total derivatives.	11	4		15
3	Jacobians: Definition & properties of Jacobians, Jacobian of an implicit functions, partial derivative of an implicit function by Jacobians, Maxima and minima up to two independent variables.	11	4	-	15
4	Tangents and Normals, Asymptotes, Curve tracing in Cartesian and polar coordinates.	13	4	-	17
	Total (in Hrs)	45	15		60

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

SUGGESTED READINGS:

1. G. B. Thomas, and R. L. Finney, Calculus, Pearson Education, Delhi.
2. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus, Dorling Kindersley (India) P. Ltd., Pearson Education, Delhi.
3. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd., Singapore.
4. S. Narayan, P. K. Mittal, Differential Calculus, S. Chand publication.
5. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
AVG.	3	3	3	3	3	3

Title of the Course : **ADVANCED CALCULUS**
Course Code : **BMA24-MJ201**
Nature of the Course : **Major**
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 elementary integration and the idea for definite integral and their applications to solve various problems.
CO2: Discuss the concept of Beta and Gamma Function with their application to compute complex problems.
CO3: Understand the concepts of rectification, quadrature, volumes and surfaces of solids of revolution.
CO4: Evaluate the double and triple integrals for solving complex problems.

UNITS	CONTENTS	L	T	P	Total Hours
1	Elementary Integration: integration of rational and irrational functions, reduction formulae (trigonometric functions, irrational, algebraic and transcendental functions), Definite integrals.	09	3	-	12
2	Beta and Gamma function with their properties, Relation between beta and gamma functions, reduction formulae, duplication formula.	10	4	-	14
3	Lengths of curves (rectification) and intrinsic equation, Area of curves (quadrature), Volumes and surfaces of solids of revolution.	13	4	-	17
4	Multiple integral: Double integration, triple integrals, change of order of integration, change of variables in double integrals and triple integrals.	13	4	-	17
	Total (in Hrs)	45	15		60

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

SUGGESTED READINGS:

1. S. Narayan, P. K. Mittal, Integral Calculus, S. Chand publication.
2. G. B. Thomas, and R. L. Finney, Calculus, Pearson Education, Delhi.
3. Shanti Narayana: A textbook of Vector Calculus, S. Chand & Co., New Delhi.
4. Murrary R. Spiegal: Theory and Problems of Advanced Calculus, Schaum Publishing Company, New York.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
AVG.	3	3	3	3	3	3

Title of the Course : ORDINARY DIFFERENTIAL EQUATIONS
Course Code : BMA24-MJ301
Nature of the Course : Major
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 linear ordinary differential equations of first and second order.
CO2: Apply different methods to solve various types of differential equations.
CO3: Examine the existence and uniqueness of solution of differential equations.
CO4: Obtain power series solutions of several important classes of ordinary differential equations.

UNITS	CONTENTS	L	T	P	Total Hours
1	Formation of differential equations, Geometrical meaning of a differential equation. Exact differential equations, integrating factors. First order higher degree equations solvable for x, y, p, Lagrange's equations, Clairaut's equations. Equation reducible to Clairaut's form. Singular solutions.	12	4	0	16
2	Linear Differential Equations with constant coefficients, homogeneous linear equation with constant coefficients, Wronskian, its properties and applications. Second order linear differential equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters.	11	4	0	15
3	Ordinary simultaneous differential equations: Solution of simultaneous differential equations, Total differential equations, Methods for finding the solution of auxiliary equations.	11	4	0	15
4	The Existence and Uniqueness of solutions: The method of successive approximation, Picard's Existence and Uniqueness theorem. Power Series: Power series solution, Ordinary and regular singular points, Series solution (Frobenius method) of first and second-order linear equations.	11	3	0	14
	Total (in Hrs)	45	15	0	60

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. M. D. Raisinghania: Ordinary and Partial Differential Equations (S. Chand).
2. Shepley L. Ross: Differential Equations (Wiley India).
3. S. G. Deo, V. Raghavendra, R. Kar, V. Laksmikanthan: Text book of Ordinary Differential Equations (McGraw Hill Education).
4. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	2	3	3	3
CO2	3	3	2	3	3	3
CO3	3	3	2	3	3	3
CO4	3	3	2	3	3	3
AVG	3	3	2	3	3	3

Title of the Course : ALGEBRA
Course Code : BMA24-MJ302
Nature of the Course : Major
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 set theoretic properties.
CO2: Understand the concepts of groups.
CO3: Classify other algebraic structures namely rings and fields.
CO4**:** Develop problem solving skills and construct systematic proofs of theorems.

UNITS	CONTENTS	L	T	P	Total Hours
1	Sets and their types viz. empty, non-empty, finite and infinite sets, Unary and binary operations on a set, Numbers and their classification, Addition and multiplication modulo operation, Existence of various properties viz. closure, associative and commutative properties in a set, Identity and inverse elements in a set, Algebraic structure, Operations between sets, Relations, Equivalence relations, Congruence modulo operation, Equivalence/residue/congruence classes, Partitions of a set, Quotient set, Composition table for finite sets, Family of sets, Mapping between sets and their types.	12	4	0	16
2	Groups and their types viz. abelian, finite and infinite, Order of a group, Basic properties of groups, Definition of group based upon left axioms, An alternative set of postulates for a group, Integral powers and order of an element group, Complexes of a group and their algebra, Subgroups of a group, Order of the product of two subgroups, Criterion for a complex to be a subgroup, Product, Intersection, Union of subgroups and related theorems.	11	4	0	15
3	Permutations on a finite set and their types viz. odd, even, cyclic and transposition, Cycle and orbits of a permutation, Group of permutations, Alternating/symmetric group, Isomorphism of groups, Cayley's theorem, Cosets of a subgroup, Coset decomposition of a group, Index of a subgroup, Lagrange's theorem, Cyclic groups and related properties.	11	4	0	15
4	Rings and their elementary properties, Rings with or without zero divisors, Subrings and related theorems, Isomorphism of rings and related theorems, Characteristic of a ring, Integral domains, Fields and subfields, Division ring or skew fields, Related theorems on fields and subfields, Characteristic of a field.	11	3	0	14
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. J. B. Fraleigh, A first course in Abstract Algebra, Addison-Wiley.
2. I. N. Herstein, Topics in Algebra, John Wiley & Sons.
3. Thomas W. Hungerford, Abstract Algebra: An Introduction, Saunders College Publishing.
4. Joseph A. Gallian, Contemporary Abstract Algebra, Brooks/Cole Cengage Learning.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	2	3	3	2
CO2	3	3	3	2	3	2
CO3	3	3	3	3	3	2
CO4	3	2	2	3	3	2
AVG.	3	2.5	2.5	2.75	3	2

Title of the Course : REAL ANALYSIS
Course Code : BMA24-MJ401
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course student will be able to
CO1: Understand real number system and learn adherent point, limit point etc.
CO2: Understand the basic concepts of limit and continuity of single variable function.
CO3: Describe sequence of real numbers.
CO4: Understand the basic concept of series, classify and apply the tests for convergence.

UNITS	CONTENTS	L	T	P	Total Hours
1	Real number system, order structure, order completeness in R, Archimedean property, countability of sets, limit point of set, equivalent set, bounded set, supremum and Infimum of sets, neighbourhood of a point, deleted neighbourhood, interior points and interior of a set, open and closed sets, adherent point, limit point, derived sets, perfect sets, dense set, compact sets, closure of a set, open cover, Bolzano-Weierstrass theorem, Heine-Borel theorem.	12	4	0	16
2	Monotonic function, squeeze theorem (statement & example), uniform continuity, boundedness theorem, intermediate value theorem, function of bounded variation.	8	4	0	12
3	Sequences of real numbers & their limits, bounded sequences, convergent sequences, limit theorem (Cauchy's first and second theorem), oscillatory & divergent sequences, subsequences, Bolzano-Weierstrass theorem for sequences, limit superior & limit inferior, algebra of convergent sequences, Cauchy's general principle of convergence, monotonic and nested sequence.	13	4	0	17
4	Infinite series, partial sums of series, necessary condition for convergence, Cauchy's criterion for convergence, test for convergence of positive term series, comparison test, Cauchy root test, Cauchy condensation test, D-Alembert's ratio test, Raabe's test, logarithmic test, Cauchy's Integral test, Abel's test, Dirichlet's test, alternating series, Leibnitz test, absolute convergence & conditional convergence.	12	3	0	15
	Total (in Hrs)	45	15		60

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. S. C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Ltd Publishers.
2. R. G. Bartle and D. R Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd.
3. K. A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag.
4. R. R. Goldberg, Method of Real Analysis, Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi.
5. B. S. Thomson, A. M. Bruckner, and J. B. Bruckner, Elementary Real Analysis, Prentice Hall.
6. W. Rudin, Principles of Mathematical Analysis, McGraw, Hill.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	2	3	3	2
CO2	3	3	2	3	3	2
CO3	3	3	2	3	3	2
CO4	3	3	2	3	3	2
AVG.	3	3	2	3	3	2

Title of the Course : PARTIAL DIFFERENTIAL EQUATIONS
Course Code : BMA24-MJ402
Nature of the Course : Major
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 partial differential equations.
CO2: Understand the concept of homogenous and non-homogenous PDEs.
CO3: Transform PDEs into canonical form.
CO4: Solve boundary value problems related to Laplace, heat and wave equations by various methods.

UNITS	CONTENTS	L	T	P	Total Hours
1	Partial differential equation: Formation of first order Linear and Non-linear PDE, Solution by Lagrange's Method, Charpit's Method and Jacobi's method.	12	4	0	16
2	Partial Differential Equations: Homogeneous linear partial differential equations with constant coefficients. Non-homogeneous linear partial differential equations with constant coefficients, Linear partial differential equations of order two with variable coefficients.	11	4	0	15
3	Classification of partial differential equation, Reduction to canonical or normal form, Monge's method.	11	3	0	14
4	Boundary value problems: Method of separation of variable, One dimensional wave equation, Two-dimensional wave equation, One dimensional heat equation, Two-dimensional heat equation, Laplace equation and solution of Laplace equation.	11	4	0	15
	Total (in Hrs)	45	15	0	60

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. G. F. Simmons, Differential equation with Applications and Historical Notes, Tata McGraw Hill.
2. W. I. Martin and E. Reissner, Elementary Differential Equations, Addison-Wesley Publishing Company.
3. I. G. Petrovaski, Ordinary Differential Equations, Moscow State University publishing.
4. I. N. Sneddon, A text book of Partial Differential Equations, McGraw Hill.
5. M. D. Raisinghania, Advanced Differential Equations, S. Chand Pub.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	***3***	***3***	***3***	***3***	3	3
CO2	***3***	***3***	***2***	***2***	3	3
CO3	***3***	***3***	***3***	***2***	3	3
CO4	***3***	***3***	***2***	***3***	3	3
AVG.	3	3	2.5	2.5	3	3

Title of the Course : **Number Theory**
Course Code : **BMA24-MJ403**
Nature of the Course : **Major**
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 Diophantine equations using division algorithm.

CO2: Examine the primality of a number.

CO3: Study public key cryptography.

CO4**:** Determine primitive roots of numbers.

UNITS	CONTENTS	L	T	P	Total Hours
1	The division algorithm, The Euclidean algorithm, Diophantine equation, The fundamental theorem of Arithmetic, The sieve of Eratosthenes, The Goldbach Conjecture.	11	3	0	14
2	Theory of Congruence, Basic properties of congruence, Special divisibility tests, Linear congruencies, Fermat's factorization method, The little theorem, Wilson's theorem.	11	4	0	15
3	Number theoretic functions, The functions τ and σ, The Mobius Inversion formula, Greatest integer function, Euler's Phi function Euler's theorem, Properties of the Phi-function.	11	4	0	15
4	The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots, Theory of indices, Euler's criterion, Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruencies with composite moduli.	12	4	0	16
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. James S. Kraft and Lawrence C. Washington, An Introduction to Number Theory with Cryptography, CRC Press, Taylor & Francis Group.
2. D. M. Burton, Elementary Number Theory, McGraw Hill.
3. I. Niven, H. S. Zuckerman and H. L. Montgomery, An Introduction to Theory of Numbers, John Wiley & Sons.
4. A. Baker, A comprehensive Course in Number Theory, Cambridge University Press.
5. George E. Andrews, Number Theory Hindustan Publishing Corporation, New Delhi.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	3	3	3	3
CO2	2	3	1	3	3	3
CO3	3	3	3	1	2	3
CO4	3	2	2	3	3	3
AVG.	2.75	2.5	2.25	2.5	2.75	3

Title of the Course : LINEAR PROGRAMMING
Course Code : BMA24-MJ501
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course, students will be able to-
CO1: Formulate real world problems as different types of linear programming problems.
CO2: Solve different types of linear programming problems by employing various techniques.
CO3: Apply duality theory to solve certain types of LPPs.
CO4: Analyse the effect of changes in various parameters on the optimal solutions of LPPs.
CO5: Solve special types of LPPs namely transportation problems and assignment problem using various methods.

UNITS	CONTENTS	L	T	P	Total Hours
1	Linear programming problems, Mathematical formulation of real-world problems, Convex sets, Supporting and separating hyper-planes, extreme points, Graphical solution of two variable Linear Programming Problems.	10	3	0	13
2	Basic feasible solutions, Theory of simplex method, Feasibility and optimality conditions, Simplex algorithm, Simplex method in tableau format, Artificial variable techniques: two-phase method, Big-M method, Cases of different types of solutions.	12	4	0	16
3	Duality Theory, Formulation of the dual problem, Primal-Dual relationship, Duality and simplex method, Dual Simplex method, Sensitivity analysis.	11	4	0	15
4	Transportation problem and its mathematical formulation, triangular basis, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, UV algorithm for solving transportation problem. Assignment problem and its mathematical formulation, Hungarian algorithm.	12	4	0	16
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. F. S. Hillier and G. J. Lieberman, *Introduction to Operations Research,* 9th Ed., Tata
   a. McGraw Hill, Singapore.
2. H. A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice-Hall, India.
3. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and*
   a. *Network Flows*, 2nd Ed., John Wiley and Sons, India.
4. P.K. Gupta, Kanti Swarup & Man Mohan, Operations Research, Sultan Chand & Co.
5. A.M. Natarajan, P. Balasubramani and A. Tamilarasi,, Operations Research, Pearson Education, India.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	3	2	3
CO5	3	3	3	3	2	3
AVG.	3	3	3	3	2	3

Title of the Course : VECTOR AND TENSOR CALCULUS
Course Code : BMA24-MJ502
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course student will be able to
CO1: Acquire knowledge of Vectors and Tensors.
CO2: Differentiate various types of tensors.
CO3: Construct correct direct and indirect proofs.

UNITS	CONTENTS	L	T	P	Total Hours
1	**Vectors:** Vectors and its algebra, Vectors products, Cartesian Vectors, Index notation, Matrix notation for vectors, Cartesian Coordinates for vectors, Cylindrical and Spherical Coordinates, Trace of Matrix, Rotations and translations of vectors.	12	4	0	16
2	Vector valued functions, Differentiation of vectors with its algebra, Curvature, directional derivatives, Fields, Gradient, Divergence, Curl, Identities, Integration of vectors, Line, Surface, Volume.	9	3	0	12
3	**Tensors:** Tensor, Order of tensors, Tensor product, Projection tensor, Dyadic, Cartesian tensors, Higher order tensors, Contraction, Index notation, Matrix notation, Identity tensor, Transpose of tensor, Trace of tensor, Normal of tensor, Determinant of tensor, Inverse of tensor, Orthogonal tensors, Rotation tensor, Change of Basis tensors, Symmetric and skew tensors, Axial vectors.	12	4	0	16
4	**Tensor Calculus:** Coordinate transformation of tensor components, Tensor Transformation Rule, Invariance of tensor Components, Tensor valued functions, Tensor derivatives, Vector fields, Gradient of Vector field, Divergence and Curl of vector field, Tensor fields, Tensor fields, Gradient of Tensor field, Divergence and Curl of Tensor field.	12	4	0	16
	Total (in Hrs)	45	15	0	60

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. R. C. Wrede, Introduction to Vector and Tensor Analysis, Dover Publications Inc., New York.
2. L. Brand, Vector Analysis, Dover Publications Inc., New York.
3. G. E. Hay, Vector and Tensor Analysis, Dover Publications Inc., New York.
4. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	2	3	2	3
AVG.	3	3	2	3	2	3

Title of the Course : LINEAR ALGEBRA
Course Code : BMA24-MJ503
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

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

CO1: Understand the concepts of vector spaces, subspaces, bases, dimension and their properties,

CO2: Understand the concepts of linear transformations, rank, nullity and algebra of linear transformations.

CO3: Relate matrices and linear transformations; compute Eigen values and Eigen vectors of linear transformations.

UNITS	CONTENTS	L	T	P	Total Hours
1.	Vector space: Introduction, subspaces, Linear combinations, linear spans, Sums and direct sums, Linear dependence and independence, Bases and dimensions, Dimensions and subspaces, Coordinates and change of bases.	12	4	0	16
2.	Linear transformations: Linear transformations, rank and nullity, Linear operators, Algebra of linear transformations, Invertible linear transformations, Isomorphism.	11	4	0	15
3.	Matrix of a linear transformation relative to ordered bases of finite-dimensional vector spaces. Correspondence between linear transformations and matrices, Linear functional: Linear functional, Dual space and dual basis, Double dual space, Annihilators, Transpose of a linear transformation.	11	4	0	15
4.	Eigen values and Eigen vectors: Eigen vectors and Eigen values of a matrix, product of characteristic roots of a matrix and basic results on characteristic roots, Cayley-Hamilton theorem and its use in finding inverse of a matrix.	11	3	0	14
	Total (inHrs)	45	15	0	60

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence: Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi.
2. David C. Lay: Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint.
3. S. Lang: Introduction to Linear Algebra, 2nd Ed., Springer.
4. Gilbert Strang: Linear Algebra and its Applications, Thomson.
5. Hoffman and Kunze: Linear Algebra, Prentice Hall of India, New Delhi.
6. H. Helson: Linear Algebra, Hindustan Book Agency, New Delhi.
7. S. Lipschutz, M. Lipson, Linear Algebra, Schaum's outline series, McGraw Hill.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	2	3	2
CO2	3	3	3	3	3	3
CO3	2	3	3	3	2	3
AVG.	2.67	3	3	2.67	2.67	2.67

Title of the Course : **Mechanics**
Course Code : **BMA24-MJ504**
Nature of the Course : **Major**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUT COMES: By the end of this course student will be able to
CO1: Determine simple harmonic equation and understand Hooke's law.
CO2: Understand Projectile, Trajectory.
CO3: Understand and evaluate virtual work.
CO4: Determine state of equilibrium, moments and couples.

UNITS	CONTENTS	L	T	P	Total Hours
1	Virtual Work: Virtual displacement and virtual work done, Difference between work done and virtual work done with examples, the principle of virtual work, Work done by the tension and thrust of an extensible string during a small displacement.	12	4	0	16
2	Equilibrium: Stable and unstable equilibrium, Moments and couples and Varignon's theorem of moments.	10	4	0	14
3	Simple Harmonic Motion: Equation of simple harmonic motion, Hooke's law for horizontal and vertical strings.	11	3	0	14
4	Projectiles: Trajectory, Velocity of projection, Angle of projection, Point of projection, Range, Time of flight and greatest height, Position of projectile at any time, Equation of trajectory, Maximum height, Maximum horizontal range of the projectile, Range and time of flight up an inclined plane.	12	4	0	16
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures ***T: Tutorials*** ***P: Practicals***
MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS:

1. F. Chorlton, Textbook of Dynamics.
2. S. L. Loney, An Elementary Treatise on the Dynamics of particle and of Rigid Bodies.
3. S. L. Loney, Elements of Statics and Dynamics I and II.
4. I. H. Shames and G. Krishna Mohan Rao, Engineering Mechanics: Statics and Dynamics, 4th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
5. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics: Statics and Dynamics, 11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	2	3	3	3
CO2	3	3	2	3	3	3
CO3	3	3	2	3	3	3
CO4	3	3	2	3	3	3
AVG	3	3	2	3	3	3

Title of the Course : **ANALYTICAL GEOMETRY**
Course Code : **BMA24-MJ601**
Nature of the Course : **Major**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUT COMES: By the end of this course student will be able to
CO1: Understand the basic concepts of cartesian and polar coordinates.
CO2: Determine the equation of a plane and their various forms.
CO3: Understand the basic knowledge of Straight lines in 3D.
CO4: Develop the concepts of Surfaces with examples and classify various conics.

UNITS	CONTENTS	L	T	P	Total Hours
1	**Coordinates and Lines:** Cartesian and polar coordinates in three dimensions, Distance between two points, Section formula, Rotation of axes and second-degree equations, Straight line and its slope, types of straight lines, Intersection of straight lines.	11	3	0	14
2	**Plane:** General form, Intercept and Normal forms. The sides of a plane. Signed distance of a point from a plane. Equation of a plane passing through the intersection of two planes. Angle between two intersecting planes.	11	4	0	15
3	**Straight lines in 3D:** Equation (Symmetric & Parametric form). Direction ratio and direction cosines. Canonical equation of the line of intersection of two intersecting planes. Angle between two lines. Distance of a point from a line. Equation of skew lines. Shortest distance between two skew lines.	11	4	0	15
4	**Surfaces:** Circle, Equation of circle with center (h, k), Spheres. Cylindrical surfaces. Central conicoid, paraboloids.	12	4	0	16
	Total (in Hrs)	45	15	0	60

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. P. R. Vittal, Analytical Geometry 2D and 3D, Pearson.
2. V. A. llyin and E. G. Poznyak, Analytical Geometry, Mir Publishers.
3. M. Postnikov, Lectures in Geometry, Firebird Publications.
4. Robert J. T. Bell, Co-ordinate Geometry of Three Dimensions, Ingram short title.
5. S. L. Loney, Co-ordinate Geometry, Arihant Publications.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	3	3	2	3
CO2	3	2	3	3	2	3
CO3	3	2	3	3	2	3
CO4	3	2	3	3	2	3
AVG.	3	2	3	3	2	3

Title of the Course : MATHEMATICAL MODELLING
Course Code : BMA24-MJ602
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course student will be able
CO1: Understand the basic concept of mathematical modelling.
CO2: Formulate and analyse various mathematical models.
CO3: Analyze the mathematical models of epidemics.
CO4: Formulate and analyse mathematical models in medicine, arm race battle and international trade.

UNITS	CONTENTS	L	T	P	Total Hours
1	Mathematical Modelling concepts: Introduction, techniques of mathematical modelling, classification of mathematical models, characteristics of mathematical models, limitations of mathematical models.	12	4	0	16
2	Continuous mathematical models (modelling through ordinary differential equations of first order): Linear growth and decay models, population growth models, effect of immigration and emigration on population size, radioactive decay, decrease of temperature, diffusion, change of price of a commodity, nonlinear growth and decay model: Logistic law of population growth, a simple compartment model.	11	4	0	15
3	Mathematical models in medicine, arms race battles and international trade in terms of system of ordinary differential equations: A model of diabetes mellitus, Richardson's model for arm race, Lanchester's combat model.	11	4	0	15
4	Discrete mathematical models (modelling through difference equations): Mathematical modelling of epidemics such as simple epidemic model, SIS model, SIS model with constant number of carriers, simple epidemic model with carriers, model with removal, model with removal and immigration, Mathematical modelling in Economics: Domar Macro model, Domar first and second debt model, Samuelson's investment model	11	3	0	14
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures ***T: Tutorials*** ***P: Practicals***
MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS:

1. J. N. Kapur: Mathematical Modelling (New Age International Private Limited).
2. B. Barnes, G. R. Fulford: Mathematical Modelling -with Case Studies: Using Maple and MATLAB (CRC Press).
3. J. N. Kapur, Mathematical models in Biology and Medicine, East-West Press.
4. F. R. Giordano, M. D. Weir and W. P. Fox, A First Course in Mathematical Modeling, Brooks Cole Publishing.
5. N. T. J. Bailey, The Mathematical Theory of Epidemics, Hafner Publishing.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
AVG.	3	3	3	3	3	3

Title of the Course : Numerical Analysis
Course Code : BMA24-MJ603
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: After completion of this course, the student will be able to
CO1: Understand approximate numbers and associated errors.
CO2: Find the roots of algebraic and transcendental equations with desired accuracy.
CO3: Determine the numerical solution of a given system of linear equations using direct methods.
CO4: Apply various interpolation formulae to interpolate discretely defined functions.
CO5: Compute numerical differentiation and integration of discretely defined functions.

UNITS	CONTENTS	L	T	P	Total Hours
1	Approximate numbers and significant digits, rounding off a number, type of errors viz. inherent, truncation, absolute, relative and percentage errors, error in addition, subtraction, multiplication, division of numbers, general error formula, error in a series approximation.	**9**	**3**		**12**
2	Solution of algebraic and transcendental equations via Bisection, Iteration, Regula-falsi, Secant and Newton-Raphson method. Numerical solution of a system of linear equations via matrix inversion, Gauss elimination, Gauss-Jordan, Crout's triangularization methods.	**12**	**4**		**16**
3	Finite difference operators viz. forward, backward, central, average, shift and divided difference operators, relation between finite difference operators, finite differences of a polynomial, missing term technique, detection of errors by finite difference table. Newton's forward and backward, Gauss's forward and backward difference, Lagrange's interpolation and Newton's divided difference interpolation formulae for unevenly spaced points.	**12**	**4**		**16**
4	Numerical differentiation and integration: Newton's forward and backward difference formula for first and second order derivatives, Numerical integration, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Error analysis of these formulae.	**12**	**4**		**16**
	Total (in Hrs)	**45**	**15**		**60**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. F. B. Hildebrand, Introduction to Numerical Analysis, McGraw Hill, N.Y.
2. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, Pvt. Ltd.
3. C. E. Froberg, Introduction to Numerical Analysis, Addison-Wesley.
4. M. K. Jain, S. R. K Iyengar and R. K. Jain, Numerical methods for Scientific and Engineering Computation, New Age International Pub.
5. R. V. Dukkipati, Applied Numerical methods, New Age International Pub.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
AVG.	3	2.8	3	3	3	3

Title of the Course : Research Ethics
Course Code : BMA24-MJ605
Nature of the Course : Major
Total Credits : 02
Distribution of Marks : 30(Ext.) + 20(Int.)

COURSE OUTCOMES: After completion of this course, the student will be able to
CO1: Understand the Philosophy and Ethics of research.
CO2: Imbibe moral values regarding scientific conduct and misconduct.
CO3: Understand and create research aptitude.
CO4: Collect and interpret the quantitative and qualitative data for analysis.

UNITS	CONTENTS	L	T	P	Total Hours
1	Philosophy: Introduction to Philosophy, Definition, Nature and Scope, Concept, branches. Ethics: Definition, moral philosophy, nature of moral judgements and reactions.	**8**	**0**	**0**	**8**
2	Scientific Conduct: Ethics with respect to science and research, Intellectual honesty and Research integrity Scientific Misconduct: Falsification, Fabrication and Plagiarism (FFP), redundant publications, duplicate and overlapping publications, Salami slicing, Selective reporting and misrepresentation of data.	**10**	**0**	**0**	**10**
3	Research Aptitude: Meaning, characteristics and types of research, steps of research. Data Interpretation: Sources, acquisition and interpretation of data, quantitative and qualitative data, graphical representation and mapping of data.	**12**	**0**	**0**	**12**
	Total (in Hrs)	**30**	**0**	**0**	**30**

L: Lectures ***T: Tutorials*** ***P: Practical***

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

SUGGESTED READINGS:

1. A. Bird, Philosophy of science, Routledge.
2. A. MacIntyre, A Short History of Ethics, Norte Dame Press, New York.
3. P. Chaddah, Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865.
4. C. R. Kothari Research Methodology, New Age International Pvt. Ltd. Publishers.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	0	0	0	0	0	2
CO2	0	0	0	2	0	3
CO3	0	0	3	3	1	3
CO4	2	0	3	3	3	3
AVG.	0.5	0	1.5	2	1	2.75

Title of the Course : FLUID DYNAMICS
Course Code : BMA24-MJ606
Nature of the Course : Major
Total Credits : 02
Distribution of Marks : 30(Ext.) + 20(Int.)

COURSE OUT COMES: By the end of this course student will be able to
CO1: Understand the concept of motion of fluids.
CO2: Apply kinematics equations of motions and determine equation of continuity.
CO3: Analyze the motion of fluids.

UNITS	CONTENTS	L	T	P	Total Hours
1	**Kinematics motion:** Real fluids and ideal fluids, velocity of a fluid at a point, streamlines and path lines, Steady and unsteady flows. The velocity potential, the vorticity vector, Local and particle rates of change, the equation of continuity, examples, acceleration of a point of a fluid.	12	0	0	12
2	**Motion of Fluid:** Pressure at a point in a fluid at rest, Pressure at a point in a moving fluid, Conditions at a boundary of two inviscid Immiscible fluids, Euler's equations of motion, Bernoulli's equation, some flows involving axial symmetry. Two- dimensional flow using cylindrical polar coordinates, the stream function. The complex potential for two dimensional irrotational, incompressible flows.	18	0	0	18
	Total (in Hrs)	**30**	**0**	**0**	**30**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. F. Chorlton, Textbook of Fluid Dynamics, CBS Publication and Distribution.
2. M. D. Raisinghania, Fluid Dynamics, S. Chand, India.
3. G. K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books.
4. L. M. Milne-Thomson, Theoretical Hydro Dynamics, Dover Publications, New York.
5. S. W. Yuan, Foundations of Fluid Mechanics, Academic Press.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PSO1**	**PSO2**
CO1	3	3	3	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
AVG.	3	3	3	3	2	3

Title of the Course : DIFFERENTIAL GEOMETRY
Course Code : BMA24-MJ607
Nature of the Course : Major
Total Credits : 02
Distribution of Marks : 30(Ext.) + 20(Int.)

COURSE OUTCOMES: By the end of this course student will be able to
CO1: Understand the fundamental concepts of plane curves and space curves.
CO2: Examine and calculate the curvature and torsion of helices for describing how it relates to the shape of curve.
CO3: Apply differential geometry techniques to specific real-world phenomena such as the behavior of flexible objects or rigid bodies.

UNITS	CONTENTS	L	T	P	Total Hours
1	Space curves: Unit vector along the tangent, Tangent line at a given point, Order of contact between curves and surfaces, Arc length, Osculating plane, Normal lines and normal plane, Principal normal, Binormal, Rectifying plane.	10	0	0	10
2	Curvature, Torsion, Skew-curvature. Serret-Frenet formulae. Directions of principal normal and binormal, cylindrical and circular Helices and their characteristic properties.	12	0	0	12
3	Locus of centre of curvature, Spherical curvature, Locus of centre of spherical curvature, Spherical indicatrix of tangent and its curvature and torsion,	8	0	0	8
	Total (in Hrs)	**30**	**0**	**0**	**30**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. C. E. Weatherburn, Differential Geometry.
2. M. M. Lipschutz, Theory and Problems of Differential Geometry, New York: McGraw Hill.
3. A. Presely, Elementry Differential Geometry, Springer.
4. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	**PO2**	**PO3**	**PO4**	**PSO1**	**PSO2**
CO1	3	3	3	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
AVG.	3	3	3	3	2	3

Title of the Course : SPECIAL FUNCTIONS
Course Code : BMA24-MJ608
Nature of the Course : Major
Total Credits : 02
Distribution of Marks : 30(Ext.) + 20(Int.)

COURSE OUTCOMES: After completion of this course, the students will be able to
CO1: Analyse the Legendre Polynomials and their properties.
CO2: Analyse the Bessel Polynomials and their properties.
CO3: Analyse the Chebyshev Polynomials and their properties.

UNITS	CONTENTS	L	T	P	Total Hours
1.	Legendre Polynomials: Legendre's equation and its solution, Generating function for Legendre polynomials, Recurrence relation, Orthogonal property of Legendre's polynomials, Rodrigue's formula	10	0	0	10
2.	Bessel Functions: Bessel's equations and its solution and their recursion relation, Orthogonal property of Bessel Functions, Rodrigue's formula.	10	0	0	10
3.	Chebyshev Polynomials: Chebyshev equation and its solution, recurrence relation, Properties of Chebyshev polynomials, orthogonal property of Chebyshev polynomial, Rodrigue's Formula.	10	0	0	10
	Total (in Hrs)	30	0	0	30

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. E. D. Rainville, Special Functions, The Macmillan Company, New York.
2. Z. X. Wang and D. R. Duo, Special Functions, World Scientific Publishing Co.
3. W.W. Bell, Special Functions for Scientist and Engineers, Dover Publications.
4. M. D. Raisinghania, Advanced Differential Equations, S. Chand Publications.
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	2	3	3	3	2	3
CO2	2	3	3	3	2	3
CO3	2	3	3	3	2	3
AVG.	2	3	3	3	2	3

Title of the Course : ADVANCED REAL ANALYSIS
Course Code : BMA24-MJ701
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course student will be able to
CO1: Understand the basic concepts of sequences, series and their convergence.
CO2: Understand the concept of Lebesgue measurability of a given set.
CO3: Understand the concept of measurable function and their properties.
CO4: Determine the Lebesgue integral of bounded and non-negative measurable functions.

UNITS	CONTENTS	L	T	P	Total Hours
1	Sequences and series of real valued functions, Pointwise and uniform convergence of sequences of functions, Pointwise and uniform convergence of series of functions, Continuity, Integrability by means of uniform convergence.	11	3	0	14
2	Equivalent sets, Countable and uncountable sets, Length of sets, Lebesgue outer measure of sets, Lebsgue measurable sets and their properties, Boolean algebra of sets, $\sigma-$Boolean algebra, Borel sets and their measurability.	11	4	0	15
3	Measurable functions and their properties, Algebra of Measurable functions, Step function, Max and min functions, Positive and negative parts of a function, Characteristics function, Simple function, Continuity of a function over measurable sets, Sets of measure zero, Almost everywhere property, Egoroff's theorem.	11	4	0	15
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.	12	4	0	16
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. R. G. Bartle, and D. R. Sherbert, Introduction to Real Analysis 4th ed. Wiley India Edition. Delhi.
2. S. R. Ghorpade and B. V. Limaye, A Course in Calculus and Real Analysis, Undergraduate Texts in Mathematics, Springer (SIE). First Indian reprint.
3. Walter Rudin, Principles of Mathematical Analysis, McGraw Hill.
4. S. C. Malik and S. Arora, Mathematical Analysis, New Age International.
5. Robert Bartle, The elements of integration and Lebesgue measure, Wiley Classics Library.
6. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.
8.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	1	3	3	3
CO2	3	3	1	3	3	3
CO3	3	3	1	3	3	3
CO4	3	3	3	3	3	3
AVG.	3	3	1.5	3	3	3

Title of the Course : MATHEMATICAL STATISTICS
Course Code : BMA24-MJ702
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

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

CO1: Describe the concept of probability, moments and expectation.

CO2: Solve problems in probability theory involving the Binomial, Poisson, Exponential and Normal distributions.

CO3: Estimate basic population parameters, construct and interpret confidence intervals to estimate means & proportions for population.

CO4**:** Determine the relation between data sets by means of correlation and regression.

UNITS	CONTENTS	L	T	P	Total Hours
1.	Probability: Sample space and Events, Three approaches of probability, Axioms of Probability, Conditional Probability, Baye's theorem, Expectations, Moments, moment generating functions, characteristic functions.	12	3	0	15
2.	Probability Distributions: Random Variables, Distribution functions, Probability density function, Discrete Random Variable, Bernoulli's Distribution, Binomial Distribution, Poisson distribution (their density functions, mean, variance, moments up to fourth order).	11	4	0	15
3.	Continuous Distributions: Continuous random variable, Normal Distribution, Uniform & Exponential distribution, sampling, types of Sampling, Test the significance, critical reason and level of significance, Null hypothesis, Test of hypothesis, Student's t-test.	11	4	0	15
4.	Testing the significance of sample mean and difference between means of two samples. Curve Fitting, methods of Least square, Correlation.	11	4	0	15
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. Miller and John Freund, Probability and Statistics, Prentice Hall.
2. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
3. M. R. Spiegel, Probability and Statistics, Schaum's Outline Series.
4. Ray, Sharma and Chaudhary, Mathematical Statistics, Ram Prasad Pub.
5. R. E. Walpole, R.H. Myers, S.l. Myers and K.Ye, Probability and Statistics for Engineers and Scientists, Pearson Pub.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	3	3	2	3
CO2	3	2	3	3	2	3
CO3	2	2	3	3	3	3
CO4	3	2	3	3	3	3
AVG.	2.75	2	3	3	2.5	3

Title of the Course : ABSTRACT ALGEBRA
Course Code : BMA24-MJ703
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: After completion of this course, the students will be able to

CO1: Understand the concepts of abstract mathematics, normal subgroups, finite groups, class equation of a group and its consequences.

CO2: Understand the concept of homomorphism in groups.

CO3: Identify and compare the properties of rings, integral domains, ideals, Euclidean rings, principal ideal rings and fields.

CO4: Understand relationships among polynomial rings, roots of polynomials and extension fields.

CO5: Understand the concept of fixed field, Galois group of a polynomial over a field.

UNITS	CONTENTS	L	T	P	Total Hours
1.	Normal subgroups, Simple groups, Conjugacy, Normalizer, Centre of a group, Class-equation of a group and its consequences, Theorems for finite groups, Cauchy's theorem, Sylow's theorem.	12	5	0	17
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.	12	3	0	15
3.	Ideals, Principal ideals, Maximal and Prime ideals, Quotient rings, Euclidean rings, Extension fields, Transitivity of finite extensions, Algebraic element, Algebraic field extensions, Minimal polynomials, Roots of polynomials, Multiple roots.	12	4	0	16
4.	Splitting field, Existence of SF of a polynomial, Automorphism of a field, Fixed field, Group of Automorphism of a field K relative by a subfield F of K, Galois group of a Polynomial over a field.	9	3	0	12
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
2. J. Fraleigh, A First Course in Abstract Algebra, Pearson Education.
3. MacDonald, Theory of Groups and Fields, Clarendon Press.
4. Khanna and Bhambari, A Course in Abstract Algebra (Vikash Pub., III Edition).
5. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

CO's No.	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	2	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	2	3	2	2
AVG.	3	3	2.6	3	2	2

Title of the Course : Ancient Indian and Vedic Mathematics
Course Code : BMA24-MJ704
Nature of the Course : Major
Total Credits : 03
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: By the end of this course, students will be able to
CO1: Discuss the rich heritage of mathematical temper of Ancient India
CO2: Enhance computational skills through Vedic Mathematics
CO3: Appreciate the Mathematical advancements of Ancient India.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction to Śulbsūtrās: Study of Baūdhāyana Śulbsūtra, Pythagoras Theorem, Addition of many squares geometrically, converting squares into a rectangle and vice-versa, squaring the circle and vice versa.	10	0		10
2	Topics from Līlāvatī of Bhāskarācārya: Eight Rules Concerning Zero, Reverse Process, Wood Cutting, Volume of a Heap of Grain, Shadows, Pulverization, Concatenation (Permutations, Partitions, etc.)	10	0		10
3	Contributions of Mahviracarya and Shridhar acarya to Jain Mathematics, Piṇgala Śastra (permutations and combinations), Brief study about acaryas namely Āryābhatta, Brahmagupta, Bhāskara II, Vārahmihira (400-1200 CE) : Life Sketch (Lineage, Period and Contribution), Kerala Mathematicians (1300-1600 CE), Indeterminate Analysis,	10	0		10
4	Simple Arithmetic calculation using Ekādhiken Pūrveṇa, Nikhil am Navatascaramam Daśtah, Urdhva-triyagabhyam & Veśtanam, Application of mental multiplication techniques and decimal division.	15	0		15
	Total (in Hrs)	**45**	**0**		**45**

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. P. Naimpally, S. L. Singh, Līlāvatī of Bhaskaracarya, Motilal Banarsidas Publishers Pvt. Ltd..
2. Swami Bharti Krishna Tirtha, Vedic Mathematics, Motilal Banarsidas Publishers Pvt. Ltd..
3. S.N. Sen and A.K. Bag., The Śulbasūtrās of Baūdhāyana, Āpastamba, Kātyāyana and Mānava with text, English translation and commentary, Publ. Indian National Science Academy, New Delhi.
4. K. D. Dwivedi, S. L. Singh, The prosody of PINGALA, Pub. Vishwavidyalya Prakashan, Varanasi.
5. S. Acharya, The Great Mathematical Heritage of India, Parimal Pub., Delhi.
6. N. Handa, O. L. Shrivastava, Ancient and Vedic Mathematics, Pub. Current Publications.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	1	1	1	1	1	1
CO2	3	1	3	3	2	1
CO3	1	1	1	1	1	1
AVG.	1.67	1	1.67	1.67	1.33	1

Title of the Course : GRAPH THEORY
Course Code : BMA24-MJ705
Nature of the Course : Major
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 various types of graphs, their terminology and applications.
CO2: Understand the concept of Digraphs, paths, circuits, Hamiltonian paths and circuits.
CO3: Perform various operations on graphs and represent graphs by means of various matrices.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction to graphs, basic properties of graphs, Simple graph, multigraph, representation of graphs, finite and infinite graphs, regular, planar graphs.	15	0	0	15
2	Directed, undirected graphs, subgraphs, walks, paths, circuits, Hamiltonian path and circuits connected graphs and connected components in a graph. Euler graphs, operations on Graphs, isomorphism of graphs.	15	0	0	15
3	Matrix representation of graphs: incidence matrix, Circuit Matrix, Adjacency matrix, Digraph, Types of Digraphs, Weighted graph, Travelling salesman problem, shortest path, Dijkstra's algorithm.	15	0	0	15
	Total (in Hrs)	**45**	0	**0**	**45**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Dover Publications.
2. F. Harary, Graph theory, Narosa Publishing House, New Delhi.
3. R. Balakrishnan and K. Renganathan, A textbook of Graph theory, Springer.
4. G. Chartrand, L. Lesniak, Graphs & digraphs. Fourth edition. Chapman & Hall/CRC.
5. Robin J. Wilson, Introduction to Graph Theory (4th Edition), Addison Wesley.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	2	2	3	3	2	3
CO2	2	2	3	3	2	3
CO3	2	2	3	3	2	3
CO4	2	2	3	3	2	3
AVG.	2	2	3	3	2	3

Title of the Course : FRACTIONAL CALCULUS
Course Code : BMA24-MJ706
Nature of the Course : Major
Total Credits : 03
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUT COMES: By the end of this course student will be able to
CO1: Discuss some special functions.
CO2: Determine fractional derivatives and integrals.
CO3: Determine the transform of fractional derivatives.

UNITS	CONTENTS	L	T	P	Total Hours
1	**Functions:** Definition of Mittag-Leffler Functions of one and two parameters, Relations of Mittag-Leffler Function to some other functions, Wright Function.	13	0	0	13
2	**Fractional derivatives and integrals:** Integral relation and Grunwald-Letnikov fractional derivatives, Riemann-Liouville fractional derivatives, Caputo's fractional derivative, Fractional derivatives of standard functions and their graphical representation, Fractional integrals.	16	0	0	16
3	**Transform of fractional derivatives:** Left and right fractional derivatives. Laplace transform of fractional derivatives, Fourier transform of fractional derivatives.	16	0	0	16
	Total (in Hrs)	**45**	0	**0**	**45**

L: Lectures ***T: Tutorials*** ***P: Practicals***
MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

Suggested Readings:

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

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	2	3
CO2	3	3	3	3	2	3
CO3	3	3	3	3	2	3
AVG.	3	3	3	3	2	3

Title of the Course : **Cryptographic Mathematics**
Course Code : **BMA24-MJ707**
Nature of the Course : **Major**
Total Credits : **03**
Distribution of Marks : **60(Ext.) + 40(Int.)**

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

CO1: Identify the easy and hard problems of cryptography using some basic number theoretic concepts.

CO2: Design cryptographic schemes for public key cryptosystem.

CO3: Recognize quantum cryptographic schemes.

CO4**:** Use cryptographic mathematics for designing quantum cryptographic schemes.

UNITS	CONTENTS	L	T	P	Total Hours
1	Division algorithm, Relatively prime numbers, Euclidean algorithm, Modular arithmetic operation, Extended Euclidean algorithm, Fermat's theorem, Euler totient function, Euler's theorem, Miller-Rabin's primality testing algorithm, Chinese remainder theorem(CRT), Pollard rho method, Primitive roots for prime numbers, Discrete logarithm and modular arithmetic logarithm, Discrete logarithm problem(DLP), Easy and hard problems.	11	0	0	11
2	Introduction to cryptography, Public key cryptography(PKC), Caesar Cipher to PKC, Knapsack cryptosystem, RSA, Application of primitive roots to RSA, Security of RSA, Diffie-Hellman(DH) key exchange algorithm, Elgamal cryptographic system, Elliptic curves over finite fields, Arithmetic operation in the set of elliptic curve points, Elliptic curve cryptography(ECC), Elliptic curve Diffie-Hellman algorithm(ECDHA), ECDLP, Security of ECC.	11	0	0	11
3	Inner, outer and tensor (Kronecker) products of vectors; Inner product of two vectors having components as complex numbers, Introduction to Hilbert space, Dirac (bra and ket) notations for vectors, Representation of column vectors of an identity matrix as smallest ket vectors $\|0\rangle$, $\|1\rangle$, $\|2\rangle$, ... etc, Standard basis for a Hilbert space, Change of basis, Projection of a vector along another vector, Representation of a vector using its projections on basis vectors, Orthogonal projections.	11	0	0	11
4	Introduction to quantum cryptography, Qubit, qutrit, ququart, qudit, multiple qubits, Quantum states and quantum superposition principle, Bloch sphere representation of qubit states, Separable (non-entangled) and non-separable quantum states, Einstein-Podolsky-Rosen(EPR) paradox, Bell states, Pure and mixed quantum states, Pauli operators, quantum operations, Joint quantum operations, Quantum gates (Bit-flip gate or not-gate or X-gate OR Pauli-X gate, Hadamard gate or H-gate, Phase shift gate, Controlled NOT gate, SWAP gate, Toffoli gate, Controlled-U gate) and circuits, Quantum measurement.	12	0	0	12
	Total (in Hrs)	**45**	**0**	**0**	**45**

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. D. M. Burton, Elementary Number Theory, Mcgraw-Hill.
2. William Stallings, Cryptography and Network Security, Pearson Education.
3. Steven D. Galbraith, Mathematics of Public Key Cryptography, Cambridge University Press, Version 2.0.
4. Martin Laforest, The Mathematics of Quantum Mechanics, University of Waterloo.

5. Michael A. Nielsen & Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, N. York.
6. James S. Kraft and Lawrence C. Washington, An Introduction to Number Theory with Cryptography, Second Edition, CRC Press
7. Lawrence C. Washington, Elliptic Curves Number Theory and Cryptography, Second Edition, Chapman & Hall/CRC Press.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	3	3	3	3
CO2	2	2	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	2	2	3	3	3
AVG.	2.75	2.25	2.75	2.5	3	3

Title of the Course : **Topology**
Course Code : **BMA24-MJ801**
Nature of the Course : **Major**
Total Credits : **04**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course student will be able to
CO1: Understand the concepts of metric spaces and topological spaces.
CO2: Describe basic results about the completeness, compactness, connectedness, continuity and convergence within these structures.
CO3: Differentiate between topological spaces T1 and T2.

UNITS	CONTENTS	L	T	P	Total Hours
1	Metric space and examples, Neighbourhood point, Open sets, Limit point, Derive set, Interior and exterior, Closed sets, Boundary of Set, Diameter of set, Convergence, Cauchy sequence, Completeness, Continuity of function in metric space, Some basic properties of continuity, Cantor intersection theorem.	12	03	0	15
2	Topological space and examples, Some elementary concept, Neighbourhood point, Basis and Sub-basis for a topology, Elementary concept of basis, Subspace topology and some basic concept, Product topology.	11	04	0	15
3	Continuity of function in topological space, Continuity theorems for open and closed sets, Homeomorphism and its examples, Connected space and examples, Elementary of connectedness, Definition of path, Components and locally connected space, Totally disconnected space.	11	04	0	15
4	Compact space and examples, Elementary of compactness, Limit point compactness, Sequentially compact space, Local compactness, Continuity and compactness, First and second countable space, T1-Space, Hausdorff spaces.	11	04	0	15
	Total (in Hrs)	45	15	0	60

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. C.A.R. Franzosa, Introduction to Topology, Narosa Pub.
2. G.F. Simmons, Introduction to Topology, Mc-Graw Hill
3. J. Munkers, Topology, Prentice Hall of India
4.Marwin J. Greenberg and J.R. Harper, Algebraic Topology, Westview Pr.
5. Schaum's outline series, General Topology, McGraw-Hill Pub.
6. Colin Adams, Introduction to Topology Pure & Applied, Pearson.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	2	2	2	2
CO2	3	3	2	2	2	2
CO3	3	3	2	2	2	2
AVG.	3	3	2	2	2	2

Title of the Course : COMPLEX ANALYSIS
Course Code : BMA24-MJ802
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

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

CO1: Understand the fundamental concepts of continuity, differentiability, analytic function and construction of an analytic function.

CO2: Integrate complex functions using Cauchy's theorem.

CO3: Expand the analytic complex functions in the form of power series.

CO4: Understand the concepts of singularities, residues, and their use in determining the complex integration.

UNITS	CONTENTS	L	T	P	Total Hours
1.	Continuity and differentiability of functions of complex variables, Branch points, Analytic and regular functions, Cauchy-Riemann equations, some properties of conjugate functions, Construction of an analytic function, Milne Thomson's method.	12	4	0	16
2.	Complex integration, Cauchy Goursat theorem, Cauchy's theorem, Morera's theorem, Cauchy's integral formulae, Cauchy inequalities, Liouville's theorem.	9	3	0	12
3.	Entire functions, Poisson's integral formulae, Power series, The circle of convergence of the power series, Taylor's series, Laurent's series.	12	4	0	16
4.	The zeros of an analytic function, Types of singularities, Residue at a single pole, Residue at a pole of order greater than unity, Residue at infinity, Cauchy's residue theorem, Evaluation of real definite integral, Integral around the unit circle.	12	4	0	16
	Total (inHrs)	45	15	0	60

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. J. W. Brown & R.V. Churchill, Complex Variables and Applications, McGraw Hill.
2. J. B. Conway, Functions of One Complex Variable, Springer.
3. Shanti Narayan, Function of Complex Variable, S. Chand.
4. S. Ponnusamy, Functions of Complex Analysis, Narosa Pub.
5. J. H. Methews & R. W. Howell, Complex Analysis for Mathematics & Engineering, Narosa Pub.
6. M. R. Spiegel, S. Lipschutz, J. J. Schiller & D. Spellman, Complex Variables, Schaum's Outline Series, McGraw Hill.
7. L. V. Ahlfors, Complex Analysis, McGraw-Hill.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	2	3	2	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
AVG.	3	3	2.75	3	2.75	3

Title of the Course : OPTIMIZATION TECHNIQUES
Course Code : BMA24-MJ803
Nature of the Course : Major
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: After completion of this course, the 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 to determine optimum game strategies.

CO3: Apply the concepts of game theory to real world competitive situations and to find out best strategy to optimize gains/losses and solution methods for two-person zero sum game problems.

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	3	0	15
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.	9	3	0	12
3.	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.	9	4	0	13
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.	15	5	0	20
	Total (in Hrs)	45	15	0	60

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 2nd Ed., John Wiley and Sons, India.
2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research,* 9th Ed., Tata McGraw Hill, Singapore.
3. Hamdy A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice---Hall India.
4. P.K. Gupta, Kanti Swarup & Man 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

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
AVG.	3	3	3	3	3	3

Title of the Course : **BASIC MATHEMATICS**
Course Code : **BMA24-MD101**
Nature of the Course : **Multi-Disciplinary Generic Elective Course**
Total Credits : **03**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course student will be able to
CO1: Understand real numbers and different progressions and their means.
CO2: Understand the concepts of set theory and matrices.
CO3: Understand different mathematical forms of straight lines.

UNITS	CONTENTS	L	T	P	Total Hours
1	Real numbers, Arithmetic progression, Geometric progression, Harmonic progression, Arithmetic mean (A.M.), Geometric mean (G.M.), Harmonic mean (H.M.), Relation between A.M., G.M. and H.M.	15	0	0	15
2	Sets and their representations, Empty set, Finite and infinite sets, Subsets, Equal sets, Power sets, Universal set, Union and Intersection of sets, Difference of two sets, Complement of a set, Venn diagram, De-Morgan's laws and their applications. Logic: Proposition, truth table, conjunction, disjunction, negation. An introduction to matrices and their types, Operations on matrices, Symmetric and skew-symmetric matrices, Minors, Co-factors. Determinant of a square matrix, Adjoint and inverse of a square matrix.	15	0	0	15
3	Straight lines, Slope of a line and angle between two lines, Different forms of equation of a line such as Parallel to co-ordinate axes, Point-slope form, Slope-intercept form, Two-point form and General form, Distance of a point from a straight line. Standard form of a circle and its properties	15	0	0	15
	Total (in Hrs)	45	0	0	45

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. C. Y. Young, Algebra and Trigonometry. Wiley.
2. S. L. Loney, The Elements of Coordinate Geometry (Cartesian Coordinates), G.K. Pub. Pvt. Ltd.
3. S. Lipschutz and M. L. Lipson, Linear Algebra, Schaum's Outline Series, McGraw-Hill.
4. C.C. Pinter, A Book of Set Theory, Dover Publications.
5. J. V. Dyke, J. Rogers and H. Adams, Fundamentals of Mathematics, Brooks/Cole.
6. A. Tussy, R. Gustafson and D. Koenig, Basic Mathematics for College Students. Brooks Cole.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	2	2	2	2	2	2
CO2	3	2	3	2	2	2
CO3	3	3	2	2	2	2
AVG.	2.67	2.33	2.33	2	2	2

Title of the Course : **BASIC PROBABILITY AND STATISTICS**
Course Code : **BMA24-MD201**
Nature of the Course : **Multi-Disciplinary Generic Elective Course**
Total Credits : **03**
Distribution of Marks : **60(Ext.) + 40(Int.)**

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

CO1: Describe probability, moments, and expectations.

CO2: Recognize different random variables in Nature and other phenomena and identify parameters

CO3: Solve basic problems in probability theory including problems involving the Bernoulli, Binomial, Poisson, Exponential and normal distributions.

CO4**:** Acquire knowledge of sampling and testing of hypothesis

UNITS	CONTENTS	L	T	P	Total Hours
1	Probability: Sample space and Events, Three approaches of probability, Axioms of Probability, Conditional Probability, Baye's theorem,	16	0	0	16
2	Probability Distributions: Random Variables, Distribution functions, Probability density function, Discrete Random Variable, Bernoulli's Distribution, Binomial Distribution, Poisson distribution (their density functions, mean, variance, moments up to fourth order)	16	0	0	16
3	Continuous Distributions: Continuous random variable, Normal Distribution, Uniform & Exponential distribution, sampling, types of Sampling, Test the significance, critical reason and level of significance, Null hypothesis, Test of hypothesis,	13	0	0	13
	Total (in Hrs)	45	0	0	45

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. Miller and John Freund, Probability and Statistics, Prentice Hall.
2. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
3. M. R. Spiegel, Probability and Statistics, Schaum's Outline Series.
4. Ray, Sharma and Chaudhary, Mathematical Statistics, Ram Prasad Pub.
5. R. E. Walpole, R.H. Myers, S.l. Myers and K.Ye, Probability and Statistics for Engineers and Scientists, Pearson Pub.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	2	3	2	2
CO2	2	2	2	2	2	3
CO3	2	3	2	3	3	3
CO4	2	2	2	2	2	2
AVG.	2.25	2.5	2	2.5	2.25	2.5

Title of the Course : **BASIC MATHEMATICAL MODELLING**
Course Code : **BMA24-MD301**
Nature of the Course : **Multi-Disciplinary Generic Elective Course**
Total Credits : **03**
Distribution of Marks : **60(Ext.) + 40(Int.)**

COURSE OUTCOMES: By the end of this course student will be able to
CO1: Understand the basic concepts of differential equation and mathematical modelling.
CO2: Classify various mathematical models through ordinary differential equations.
CO3: Formulate and analyze the modelling through population dynamics.

UNITS	CONTENTS	L	T	P	Total Hours
1	Mathematical Modelling concepts: Introduction, techniques of mathematical modelling, classification of mathematical models, characteristics of mathematical models, limitations of mathematical models.	14	0	0	14
2	Introduction to differential equation of first order and first degree: Separation of variable method, homogeneous equation, linear differential equations. Continuous mathematical models: Linear growth and decay models, population growth models, effect of immigration and emigration on population size, radioactive decay, decrease of temperature, diffusion, change of price of a commodity, a simple compartment model.	15	0	0	15
3	Discrete mathematical models: Prey predator model, Mathematical model for epidemics: A simple epidemic model, SIS model, SIS model with constant number of carriers, simple epidemic model with carriers, model with removal, model with removal and immigration. Mathematical modelling in Economics: Domar Macro model, Domar first and second debt model, Samuelson's investment model	16	0	0	16
	Total (in Hrs)	45	0	0	45

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand.
2. J. N. Kapur, Mathematical Modelling, New Age International Private Limited.
3. J. N. Kapur, Mathematical models in Biology and Medicine, East-West Press.
4. N. T. J. Bailey, The Mathematical Theory of Epidemics, Hafner Publishing.
5. F.R. Giordano, M.D. Weir and W.P. Fox, A First Course in Mathematical Modeling, Brooks Cole Publishing.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
AVG.	3	3	3	3	3	3

Title of the Course : DIFFERENTIAL EQUATIONS
Course Code : BMA24-MI401
Nature of the Course : Minor
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

By the end of this course student will be able to
CO1: Understand differential equations.
CO2: Recognize wide ranging application of the differential equations and classify linear and non-linear equations.
CO3: Develop problem solving skills for solving various types of differential equations.

UNITS	CONTENTS	L	T	P	Total Hours
1	Formation of differential equations, Order and Degree of Differential Equations, Complete primitive (general solution, particular solution and singular solutions), The Wronskian. Equation of first order and first degree: Separation of variables, Homogeneous equations, Equation reducible to homogeneous form, Linear equations, differential equations reducible to linear form.	12	4	0	16
2	Equation of first order and first degree: Exact differential equations, Condition of exactness, Integrating factor, Rules for finding integrating factor.	11	3	0	14
3	Higher order linear differential equations with constant coefficients: Complementary function, Particular integral (PI), Methods for finding PI. Homogeneous linear equation (or Cauchy-Euler equations) and Equations reducible to homogeneous linear form.	11	4	0	15
4	Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations. Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.	11	4	0	15
	Total (in Hrs)	45	15	0	60

L: Lectures T: Tutorials P: Practicals
MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS:

1. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand.
2. S. L. Ross, Differential Equations, Wiley India.
3. Suggested online platform: NPTEL/SWAYAM/MOOCs

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	3	3
CO2	3	3	3	3	2	3
CO3	2	3	3	2	3	2
AVG.	2.67	3	3	2.67	2.67	2.67

Title of the Course : LINEAR ALGEBRA
Course Code : BMA24-MI501
Nature of the Course : Minor
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

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

CO1: Understand the concepts of vector spaces, subspaces, bases, dimension and their properties,

CO2: Understand the concepts of linear transformations, rank, nullity and algebra of linear transformations.

CO3: Relate matrices and linear transformations; compute Eigen values and Eigen vectors of linear transformations.

UNITS	CONTENTS	L	T	P	Total Hours
1.	Vector space: Introduction, subspaces, Linear combinations, linear spans, Sums and direct sums, Linear dependence and independence, Bases and dimensions, Dimensions and subspaces, Coordinates and change of bases.	12	4	0	16
2.	Linear transformations: Linear transformations, rank and nullity, Linear operators, Algebra of linear transformations, Invertible linear transformations, Isomorphism.	11	4	0	15
3.	Matrix of a linear transformation relative to ordered bases of finite-dimensional vector spaces. Correspondence between linear transformations and matrices, Linear functional: Linear functional, Dual space and dual basis, Double dual space, Annihilators, Transpose of a linear transformation.	11	4	0	15
4.	Eigen values and Eigen vectors: Eigen vectors and Eigen values of a matrix, product of characteristic roots of a matrix and basic results on characteristic roots, Cayley-Hamilton theorem and its use in finding inverse of a matrix.	11	3	0	14
	Total (in Hrs)	45	15	0	60

L: Lectures ***T: Tutorials*** ***P: Practicals***

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

SUGGESTED READINGS:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence: Linear Algebra, 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi.
2. David C. Lay: Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint.
3. S. Lang: Introduction to Linear Algebra, 2nd Ed., Springer.
4. Gilbert Strang: Linear Algebra and its Applications, Thomson.
5. Hoffman and Kunze: Linear Algebra, Prentice Hall of India, New Delhi.
6. H. Helson: Linear Algebra, Hindustan Book Agency, New Delhi.
7. S. Lipschutz, M. Lipson, Linear Algebra, Schaum's outline series, McGraw Hill.
8. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	2	3	2
CO2	3	3	3	3	3	3
CO3	2	3	3	3	2	3
AVG.	2.67	3	3	2.67	2.67	2.67

Title of the Course : Numerical Analysis
Course Code : BMA24-MI601
Nature of the Course : Minor
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: After completion of this course, the student will be able to
CO1: Understand approximate numbers and associated errors.
CO2: Find the roots of algebraic and transcendental equations with desired accuracy.
CO3: Determine the numerical solution of a given system of linear equations using direct methods.
CO4: Apply various interpolation formulae to interpolate discretely defined functions.
CO5: Compute numerical differentiation and integration of discretely defined functions.

UNITS	CONTENTS	L	T	P	Total Hours
1	Approximate numbers and significant digits, rounding off a number, type of errors viz. inherent, truncation, absolute, relative and percentage errors, error in addition, subtraction, multiplication, division of numbers, general error formula, error in a series approximation.	**9**	**3**		**12**
2	Solution of algebraic and transcendental equations via Bisection, Iteration, Regula-falsi, Secant and Newton-Raphson method. Numerical solution of a system of linear equations via matrix inversion, Gauss elimination, Gauss-Jordan, Crout's triangularization methods.	**12**	**4**		**16**
3	Finite difference operators viz. forward, backward, central, average, shift and divided difference operators, relation between finite difference operators, finite differences of a polynomial, missing term technique, detection of errors by finite difference table. Newton's forward and backward, Gauss's forward and backward difference, Lagrange's interpolation and Newton's divided difference interpolation formulae for unevenly spaced points.	**12**	**4**		**16**
4	Numerical differentiation and integration: Newton's forward and backward difference formula for first and second order derivatives, Numerical integration, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Error analysis of these formulae.	**12**	**4**		**16**
	Total (in Hrs)	**45**	**15**		**60**

L: Lectures T: Tutorials P: Practicals
MODES OF IN-SEMESTER ASSESSMENT: Seminar, Quiz, Continuous Assessment Tests, etc.

SUGGESTED READINGS:

1. F. B. Hildebrand, Introduction to Numerical Analysis, McGraw Hill, N.Y.
2. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, Pvt. Ltd.
3. C. E. Froberg, Introduction to Numerical Analysis, Addison-Wesley.
4. M. K. Jain, S. R. K Iyengar and R. K. Jain, Numerical methods for Scientific and Engineering Computation, New Age International Pub.
5. R. V. Dukkipati, Applied Numerical methods, New Age International Pub.
6. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
AVG.	3	2.8	3	3	3	3

Title of the Course : MATHEMATICAL STATISTICS
Course Code : BMA24-MI701
Nature of the Course : Minor
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

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

CO1: Describe the concept of probability, moments and expectation.

CO2: Solve problems in probability theory involving the Binomial, Poisson, Exponential and Normal distributions

CO3: Estimate basic population parameters, construct and interpret confidence intervals to estimate means and proportions for population.

CO4**:** Determine the relation between data sets by means of correlation and regression.

UNITS	CONTENTS	L	T	P	Total Hours
1.	Probability: Sample space and Events, Three approaches of probability, Axioms of Probability, Conditional Probability, Baye's theorem, Expectations, Moments, moment generating functions, characteristic functions.	12	3	0	15
2.	Probability Distributions: Random Variables, Distribution functions, Probability density function, Discrete Random Variable, Bernoulli's Distribution, Binomial Distribution, Poisson distribution (their density functions, mean, variance, moments up to fourth order).	11	4	0	15
3.	Continuous Distributions: Continuous random variable, Normal Distribution, Uniform & Exponential distribution, sampling, types of Sampling, Test the significance, critical reason and level of significance, Null hypothesis, Test of hypothesis, Student's t-test.	11	4	0	15
4.	Testing the significance of sample mean and difference between means of two samples. Curve Fitting, methods of Least square, Correlation.	11	4	0	15
	Total (in Hrs)	**45**	**15**	**0**	**60**

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. Miller & Johan, Freund Probability and Statistics, Prentice Hall.
2. Miller and John Freund, Probability and Statistics, Prentice Hall.
3. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
4. M. R. Spiegel, Probability and Statistics, Schaum's Outline Series.
5. Ray, Sharma and Chaudhary, Mathematical Statistics, Ram Prasad Pub.
6. R. E. Walpole, R.H. Myers, S.l. Myers and K.Ye, Probability and Statistics for Engineers and Scientists, Pearson Pub.
7. Suggested online platform: NPTEL/SWAYAM/MOOCs.

CO-PO-PSO MAPPING

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	2	3	3	2	3
CO2	3	2	3	3	2	3
CO3	2	2	3	3	3	3
CO4	3	2	3	3	3	3
AVG.	2.75	2	3	3	2.5	3

Title of the Course : OPTIMIZATION TECHNIQUES
Course Code : BMA24-MI801
Nature of the Course : Minor
Total Credits : 04
Distribution of Marks : 60(Ext.) + 40(Int.)

COURSE OUTCOMES: After completion of this course, the 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 to determine optimum game strategies.

CO3: Apply the concepts of game theory to real world competitive situations and to find out best strategy to optimize gains/losses and solution methods for two-person zero sum game problems.

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	3	0	15
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.	9	3	0	12
3.	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.	9	4	0	13
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.	15	5	0	20
	Total (in Hrs)	45	15	0	60

L: Lectures T: Tutorials P: Practicals

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

SUGGESTED READINGS:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 2nd Ed., John Wiley and Sons, India.
2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research,* 9th Ed., Tata McGraw Hill, Singapore.
3. Hamdy A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice---Hall India.
4. P.K. Gupta, Kanti Swarup & Man Mohan, Operations Research, S. 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

	PO1	PO2	PO3	PO4	PSO1	PSO2
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
AVG.	3	3	3	3	3	3