Anekant Education Society's

Tuljaram Chaturchand Collge of Arts, Science and Commerce, Baramati.

(Autonomous)

Course & Credit Structure for S.Y.B.Sc. Mathematics (2023 Pattern as per NEP 2020)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
III	Major Mandatory	MAT-201-MJM	Calculus of Several Variables	Theory	02
	Major Mandatory	MAT-202-MJM	Laplace Transform & Fourier Series	Theory	02
	Major Mandatory	MAT-203-MJM	Ordinary Differential Equations	Theory	02
	Major Mandatory	MAT-204-MJM	Mathematics Practical III	Practical	02
	Minor	MAT-211-MN	Foundations of Linear Algebra	Theory	02
	Minor	MAT-212-MN	Practical based on Ordinary Differential Equations	Practical	02
	Open Elective (OE)	MAT-216-OE	Intermediate Mathematics	Theory	02
	Vocational Skill Course (VSC)	MAT-221-VSC	Financial Mathematics	Theory	02
	Ability Enhancement Course (AEC)	MAR-231-AEC HIN-231-AEC SAN-231-AEC	भाषिक उपयोजन व लेखन कौशल्ये हिंदी भाषा: श्रुजन कौशल प्राथमिक संभाषणकौशल्यम्	Theory	02
	Field Project (FP)	MAT-235-FP	Field Project	Practical	02
	Co-curricular Course (CC)	YOG/PES/CUL/NSS/NCC-239-CC	To be selected from the Basket	Theory	02
	Generic IKS Course (IKS)	GEN-245-IKS		Theory	02
				Total Credits Semester-III	**24**
IV	Major Mandatory	MAT-251-MJM	Vector Calculus	Theory	02
	Major Mandatory	MAT-252-MJM	Linear Algebra	Theory	02
	Major Mandatory	MAT-253-MJM	Operations Research	Theory	02
	Major Mandatory	MAT-254-MJM	Mathematics Practical IV	Practical	02
	Minor	MAT-261-MN	Multivariable Calculus	Theory	02
	Minor	MAT-262-MN	Practical based on Partial Differential Equations	Practical	02
	Open Elective (OE)	MAT-266-OE	Mathematical Methods	Practical	02
	Skill Enhancement Course (SEC)	MAT-276-SEC	Geogebra Software	Practical	02
	Ability Enhancement Course (AEC)	MAR-281-AEC HIN-281-AEC SAN-281-AEC	लेखन निर्मिती व परीक्षण कौशल्ये हिंदी भाषा: संप्रेषण कौशल प्रगत संभाषणकौशल्यम्	Theory	02
	Community Engagement Project (CEP)	MAT-285-CEP	Community Engagement Project	Practical	02
	Co-curricular Course (CC)	YOG/PES/CUL/NSS/NCC-289-CC	To be selected from the Basket	Theory	02
				Total Credits Semester-IV	**22**
				Cumulative Credits Semester III + Semester IV	**46**

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Major Mandatory
Course Name	**:** Vector Calculus
Course Code	**:** MAT-251-MJM
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To develop a solid foundation in double integrals, focusing on their evaluation over rectangular and general regions, including the use of polar coordinates.
2. To gain proficiency in evaluating triple integrals and understanding their applications, particularly in different coordinate systems such as cylindrical and spherical coordinates.
3. To learn and apply the technique of changing variables in multiple integrals to simplify complex integrals in various coordinate systems.
4. To introduce vector fields and the concept of line integrals, and to explore their fundamental properties and applications.
5. To understand and apply the fundamental theorem for line integrals, as well as Green's theorem, to solve problems involving vector fields.
6. To study surface integrals and the associated concepts of curl and divergence, and to apply the theorems of Stokes and Gauss (Divergence) in practical situations.
7. To explore the real-world applications of double, triple, line, and surface integrals in various fields, including physics, engineering, and geometry.

Course Outcomes:

CO1: Students will be able to evaluate double integrals over rectangular and general regions and apply these integrals to solve problems in polar coordinates.
CO2: Students will demonstrate the ability to compute triple integrals in Cartesian, cylindrical, and spherical coordinates and apply them to relevant problems.
CO3: Students will be able to apply the change of variables technique in multiple integrals to simplify complex integrals.
CO4: Students will be able to understand and analyze vector fields, calculate line integrals, and apply the fundamental theorem for line integrals in practical situations.
CO5: Students will demonstrate the ability to apply Green's theorem to convert line integrals into double integrals and solve related problems.
CO6: Students will be able to evaluate surface integrals, understand parametric surfaces, and apply concepts like curl, divergence, Stokes' theorem, and the divergence theorem in practical contexts.
CO7: Students will be able to apply their understanding of double, triple, line, and surface integrals to solve real-world problems in physics, engineering, and other fields.

Topics and Learning Points

Teaching Hours

Unit 1: Double Integrals **08**

1.1 Double integrals over rectangles
1.2 Iterated integrals
1.3 Double integrals over general regions
1.4 Double integrals in polar coordinates
1.5 Applications of double integrals

Unit 2: Triple Integrals **07**

2.1 Triple integrals
2.2 Triple integrals in cylindrical coordinates
2.3 Triple integrals in spherical coordinates
2.4 Change of variables in multiple integrals
2.5 Applications of triple integrals

Unit 3: Line Integrals **07**

3.1 Vector fields
3.2 Line integrals
3.3 The fundamental theorem for line integrals
3.4 Green's theorem

Unit 4: Surface Integrals **08**

4.1 Curl and divergence
4.2 Parametric surfaces and their areas
4.3 Surface integrals
4.4 Stoke's theorem
4.5 The divergence theorem

Text Books:

1. James Stewart, *Calculus with Early Transcendental Functions*, Cengage Learning, Indian Edition

   Unit 1: Sections 15.1 to 15.5, **Unit 2:** Sections 15.6 to 15.9,
   Unit 3: Sections 16.1 to 16.4, **Unit 4:** Sections 16.5 to 16.9.

Reference Books:

1. G. B. Thomas, *Thomas' Calculus*, Pearson, Edition 2012.
2. Tom M. Apostol, *Calculus Vol. II*, John Wiley.
3. Shanti Narayan and R. K. Mittal, *A text-book of Vector Calculus*, S. Chand and Company.
4. J. E. Marsden, A. J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer.
5. D. V. Widder, *Advanced Calculus*, Printice Hall of India.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	3	3	3	3	3	3
PO2	2	2	2	2	2	3	3
PO3						1	1
PO4	3	2	3	3	3	3	3
PO5	3	3	3	3	3	3	3
PO6				2	2	2	2
PO7				2	2	2	3
PO8	2	2	2	2	2	3	3
PO9	2	2	2	2	2	3	3
PO10	1	1	1	1	1	2	2
PO11						1	1
PO12	1	1	1	2	2	2	3
PO13	1	1	1	1	1	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - Each CO's require students to develop a deep understanding of multiple integrals, vector calculus, and related theorems, which are fundamental mathematical concepts.

PO2: ***Practical, professional, and procedural knowledge*** - CO1 to CO5 involve applying mathematical theories to solve problems, which helps in building professional and procedural knowledge and CO6 and CO7 involve complex applications of mathematical theorems to practical problems, enhancing professional and practical knowledge.

PO3: ***Entrepreneurial mindset and knowledge*** **-** The application of integrals in real-world problems can inspire entrepreneurial solutions in fields like engineering and physics.

PO4: ***Specialized skills and competencies*** - The mastery of integrals and theorems covered under CO1 and CO3 to CO7 equips students with specialized skills necessary for advanced fields in mathematics, physics, and engineering. While CO2 focused on triple integrals, it contributes to specialized knowledge but slightly less than other COs that apply multiple advanced theorems.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - All COs require students to apply mathematical concepts to solve complex problems, thereby developing strong analytical and problem-solving abilities.

PO6: ***Communication skills and collaboration*** - As students CO4 to CO7 concepts in practical situations, effective communication and collaboration may be required, especially in real-world problem-solving.

PO7: ***Research-related skills*** - Analyzing vector fields and applying theorems can involve research-oriented thinking whereas applying advanced theorems and solving real-world problems involves significant research-related skills.

PO8: ***Learning how to learn skills*** - Learning integrals and vector fields fosters an ongoing learning mindset and applying complex theorems to new problems requires continuous learning and adaptability.

PO9: ***Digital and technological skills*** - Some problems may involve digital tools for calculations or simulations whereas applying CO4 to CO7's concepts often involve the use of advanced software or technology in problem-solving.
PO10: ***Multicultural competence, inclusive spirit, and empathy*** - CO1 to CO5 are technical and do not directly address multicultural competence or empathy but solving real-world problems can require understanding different contexts and working collaboratively, fostering an inclusive spirit.
PO11: ***Value inculcation and environmental awareness*** - Applying mathematical concepts in CO6 and CO7 to environmental problems (e.g. calculating areas, volumes related to environmental science) can increase awareness.
PO12: ***Autonomy, responsibility, and accountability*** - CO1 to CO3 primarily focus on individual understanding, with less emphasis on autonomy or responsibility, CO4 and CO5 requires a degree of responsibility and accountability and solving practical problems often requires independent thinking, accountability, and responsibility.
PO13: ***Community engagement and service*** - CO1 to CO5 are technical and not directly related to community engagement whereas real-world applications of integrals can be connected to community issues, such as environmental modeling or engineering solutions for societal benefits.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Major Mandatory
Course Name	**:** Linear Algebra
Course Code	**:** MAT-252-MJM
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To introduce students to the fundamental concepts of vector spaces, including definitions, examples, subspaces, and the concept of basis and dimension.
2. To provide a thorough understanding of quotient spaces and their significance within vector spaces.
3. To develop a strong foundation in linear transformations, including their representation by matrices and the concepts of kernel and image.
4. To explore linear isomorphisms and special types of linear transformations, emphasizing their applications in various mathematical contexts.
5. To familiarize students with inner product spaces and the concept of orthogonality, along with orthogonal projections and transformations.
6. To introduce students to the concepts of eigenvalues and eigenvectors, including their importance in the rotation of axes and other applications.
7. To understand the Cayley-Hamilton theorem and its implications for linear transformations and matrix theory.

Course Outcomes:

CO1: Students will be able to define and identify vector spaces, subspaces, and determine the basis and dimension of a given vector space.
CO2: Students will be able to construct and analyze quotient spaces, demonstrating their understanding of the structure of vector spaces.
CO3: Students will be able to represent linear transformations using matrices and compute the kernel and image of a given transformation.
CO4: Students will gain the ability to identify and apply linear isomorphisms and special linear transformations in various mathematical problems.
CO5: Students will demonstrate a strong understanding of inner product spaces, including the ability to work with orthogonality, orthogonal projections, and orthogonal transformations.
CO6: Students will be able to compute and interpret eigenvalues and eigenvectors, and apply them to problems involving rotations of axes and other transformations.
CO7: Students will understand and apply the Cayley-Hamilton theorem to solve problems related to linear transformations and matrix theory.

Topics and Learning Points

	Teaching Hours
Unit 1: Vector Spaces	**12**
1.1 Definitions and Examples	
1.2 Vector Subspaces	
1.3 Basis and Dimensions of a Vector Space	
1.4 Quotient Space	
Unit 2: Linear Transformations	**12**
2.1 Linear Transformation	
2.2 Representation of Linear Map by Matrix	
2.3 Kernel and Image of a Linear Transformation	
2.4 Linear Isomorphism	
2.5 Some special Linear Transformations	
Unit 3: Inner Product spaces	**15**
3.1 Inner Product Spaces	
3.2 Orthogonality	
3.3 Orthogonal Projection onto a Line	
3.4 Orthogonal Basis	
3.5 Orthogonal Completeness and Projections	
3.6 Orthogonal Transformation	
Unit 4: Eigen values and Eigen vectors	**06**
4.1 Rotation of Axes of Conics	
4.2 Eigenvalues and Eigenvectors	
4.3 Cayley-Hamilton theorem	

Text Books:

S. Kumaresan, *Linear Algebra: A Geometric Approach*, Prentice Hall of India, New Delhi

Unit 1: Sections 2.1 to 2.3 and 3.3, **Unit 2:** Sections 4.1 to 4.4 and 4.6,
Unit 3: Sections 5.1 to 5.6 and 5.8, **Unit 4:** Sections 7.1 and 7.2.

Reference Books:

1. M. Artin, *Algebra*, Prentice Hall of India, New Delhi, (1994).
2. K. Hoffmann and R. Kunze, *Linear Algebra*, Prentice Hall of India.
3. S. Lang, *Introduction to Linear Algebra*, Springer-Verlag, New Yark.
4. G. Schay, *Introduction to Linear Algebra*, Narosa, New Delhi, (1998).
5. L. Smith, *Linear Algebra*, Springer –Verlag, New York, (1978).
6. G. Strang, *Linear Algebra and its Applications*, Harcourt Brace Jovanovich.
7. T. Banchoff and J. Werner, *Linear Algebra through Geometry*, Springer-Verlag.
8. H. Anton and C. Rorres, *Elementary Linear Algebra with Applications*, Wiley, (1994).
9. A. Ramchandra Rao and P. Bhimasankaran, *Linear Algebra*, Tata McGraw Hill.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	3	3	3	3	3	3
PO2	2	2	3	3	2	3	3
PO3			1	1		1	
PO4	2	2	3	3	3	3	3
PO5	3	3	3	3	3	3	3
PO6				1	1		
PO7	1	2	2	2	2	2	2
PO8	2	2	3	3	3	3	3
PO9	1	1	3	2	2	3	3
PO10							
PO11							
PO12	1	1	1	2	2	2	2
PO13							

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - All COs contribute directly to the foundational understanding of vector spaces, transformations, and theorems.
PO2: ***Practical, professional, and procedural knowledge*** - CO3, CO4, CO6, CO7 emphasize practical applications of linear algebra in problem-solving and analysis.
PO3: ***Entrepreneurial mindset and knowledge*** - CO3, CO4, CO6 encourage problem-solving and innovation in various mathematical applications.
PO4: ***Specialized skills and competencies*** - CO3, CO4, CO5, CO6, CO7 develop specialized skills in linear algebra and matrix theory.
PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - Every CO builds analytical reasoning and problem-solving skills related to vector spaces and transformations.
PO6: ***Communication skills and collaboration*** - Collaboration is indirectly encouraged through problem-solving (CO4, CO5), but not the primary focus.
PO7: ***Research-related skills*** - CO2 to CO7 contribute moderately to research skills, encouraging deep mathematical inquiry.
PO8: ***Learning how to learn skills*** - Every CO pushes students to independently develop their skills and knowledge.
PO9: ***Digital and technological skills*** - CO3, CO6, CO7 involve computation and technology for matrices and transformations.
PO12: ***Autonomy, responsibility, and accountability*** - Independence in problem-solving and accountability is developed across COs, especially CO4 to CO7.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Major Mandatory
Course Name	**:** Operations Research
Course Code	**:** MAT-253-MJM
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To familiarize students with the basic concepts, terminologies, and constraints involved in linear programming problems, enabling them to articulate problem formulations effectively.
2. Develop students' proficiency in graphically representing and solving linear programming problems using the graphical method, including identifying feasible regions, optimal solutions, and sensitivity analysis.
3. Enable students to apply the simplex method algorithmically to solve complex linear programming problems, emphasizing the understanding of pivot operations and iterations.
4. To enable students to understand and apply the concept of duality in Linear Programming (LP) problems, exploring its significance, properties, and practical implications.
5. To familiarize students with the core concepts, algorithms, and mathematical techniques used in transportation modeling, enabling them to comprehend the underlying principles of optimization in transportation systems.
6. To equip students with the ability to identify, formulate, and solve transportation problems using appropriate mathematical models and optimization techniques. This includes practical applications in logistics, supply chain management, and urban transportation planning.
7. To familiarize students with the fundamental principles and concepts underlying assignment models in Operations Research, including the Hungarian method, transportation problems, and linear programming techniques used in solving assignment problems.

Course Outcomes:

CO1: Students will demonstrate the ability to formulate real-world problems into mathematical linear programming models, identifying decision variables, constraints, and the objective function accurately.
CO2: Students will be able to graphically solve and interpret linear programming problems, accurately identifying feasible regions, and optimal solutions.
CO3: Students will apply the simplex method proficiently to solve multi-variable linear programming problems, showcasing competence in formulating initial tables, conducting iterations, and identifying optimal solutions.
CO4: Students will exhibit proficiency in applying the Big-M method to solve problems with artificial variables, manipulating constraints effectively, and transitioning between phases while solving LP problems.

CO5: Students will be able to explain the concept of duality in Linear Programming, outlining its mathematical basis and relevance in optimization problems.

CO6: Students will be able to develop and implement transportation models to optimize logistical operations, effectively analyze transportation networks, and propose strategic solutions for minimizing transportation costs, maximizing efficiency, and addressing complex real-world transportation challenges.

CO7: Students will be proficient in formulating assignment problems in different contexts (such as workforce allocation, resource assignment, task optimization) as mathematical models. They will demonstrate the capability to apply appropriate algorithms and techniques, like the Hungarian algorithm or linear programming, to solve these assignment problems efficiently and effectively.

Topics and Learning Points

	Teaching Hours
Unit 1: Modeling with Linear Programming	**08**
1.1 Two variable LP Model	
1.2 Graphical LP solution	
1.3 Special cases in solution of graphical method	
1.4 Selected LP Applications	
Unit 2: The Simplex Method	**08**
2.1 LP Model in equation form	
2.2 The simplex method	
2.3 Big-M method	
2.4 Special cases in solution of simplex method	
Unit 3: Duality	**02**
3.1 Definition of the dual problem	
3.2 Primal dual relationship	
Unit 4: Transportation Model	**08**
4.1 Definition of the Transportation model	
4.2 Different methods to find initial basic feasible solution (IBFS)	
4.3 The Modified Distribution method (MODI)	
4.4 Special cases in solution of transportation problem	
4.5 Maximization case in transportation problem	
Unit 5: Assignment Model	**04**
9.1 Definition of the Transportation model	
9.2 The Hungarian method	
9.3 Maximization case in assignment problem	

Text Books:

J. K. Sharma, *Operations Research: Theory and Applications*, (2nd Edition, 2006), Macmilan India Ltd.

Unit 1: Ch. 2 &3 **Unit 2:** Ch. 4 **Unit 3:** Ch. 5
Unit 4: Ch. 9 **Unit 5:** Ch. 10

Reference Books:

1. Hamdy A. Taha, *Operation Research* (8th Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.
2. Frederick S. Hillier, Gerald J. Lieberman, *Introduction to Operation Research* (8th Edition) Tata McGraw Hill.
3. Hira and Gupta, *Operation Research*.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	2	3	3	3	3	3
PO2	2	2	3	3	2	3	3
PO3	1		2	2		2	2
PO4	1	1	2	2	1	2	2
PO5	3	3	3	3	3	3	3
PO6						2	2
PO7	2		2	2	2	2	2
PO8	2	2	2	2	2	2	2
PO9	2	2	2	2	2	2	2
PO10						2	2
PO11						1	1
PO12	2	2	2	2	2	2	2
PO13						2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - CO1 involves formulating real-world problems into linear programming models, requiring a deep understanding of mathematical concepts, CO3 and CO4 focus on solving linear programming problems using the simplex and Big-M methods, demanding thorough knowledge of the concepts and CO6 and CO7 require understanding and applying optimization models, which aligns with comprehensive knowledge in optimization and operations research.

PO2: ***Practical, professional, and procedural knowledge*** - CO3, CO4, CO6 and CO7 emphasize the application of algorithms and models in real-world scenarios, showcasing procedural knowledge and CO1, CO2 and CO5 focus on the practical implementation of transportation and assignment models, which require professional and procedural knowledge.

PO3: ***Entrepreneurial mindset and knowledge*** - CO3, CO4, CO6, and CO7 require innovative thinking to optimize resources, a key aspect of entrepreneurial knowledge and CO1 encourages students to think creatively when formulating linear programming models.

PO4: ***Specialized skills and competencies*** - CO3, CO4, CO6, and CO7 develop specialized skills in optimization, mathematical modeling, and algorithm application, which are crucial competencies in operations research and related fields.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - All COs are directly related to problem-solving and analytical reasoning, as students are required to solve linear programming problems, apply algorithms, and optimize operations.

PO6: ***Communication skills and collaboration*** - CO6 and CO7 involve collaboration and communication, especially when presenting solutions to complex real-world problems.

PO7: ***Research-related skills*** - CO1, CO3, CO4, CO5, CO6, and CO7 involve research skills in understanding and applying advanced concepts like duality, the simplex method, and transportation models.

PO8: ***Learning how to learn skills*** - All COs contribute to the ability to learn new concepts and techniques, especially when exploring advanced topics like duality, transportation, and assignment models.

PO9: ***Digital and technological skills*** - All COs require students to use software tools and digital techniques for modeling and solving problems, enhancing their technological skills.
PO10: ***Multicultural competence, inclusive spirit, and empathy*** - CO6 and CO7 slightly contribute to this PO, as they involve considerations in logistics and resource allocation that can impact diverse populations.
PO11: ***Value inculcation and environmental awareness*** - CO6 and CO7 may indirectly contribute to this PO by considering sustainable and efficient use of resources in transportation and assignment problems.
PO12: ***Autonomy, responsibility, and accountability*** - All COs require students to take responsibility for their learning and solutions, particularly in independent problem-solving tasks.
PO13: ***Community engagement and service*** - CO6 and CO7 can relate to community service through optimization of resources that benefit society, although this connection is minimal.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Major Mandatory
Course Name	**:** Mathematics Practical IV
Course Code	**:** MAT-254-MJM
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To develop a comprehensive understanding of double and triple integrals and their applications in calculating areas, volumes, mass, and other physical quantities.
2. To equip students with the ability to evaluate work done by force fields and calculate surface integrals and flux in vector fields.
3. To provide students with a strong foundation in vector spaces, linear transformations, and the theoretical underpinnings of linear algebra.
4. To enable students to apply eigenvalues and eigenvectors in diagonalization, stability analysis, and other relevant contexts.
5. To foster a deep understanding of inner product spaces, focusing on orthogonality, projections, and the Gram-Schmidt process.
6. To introduce students to the practical applications of linear programming and the simplex method for optimizing resource allocation in various scenarios.
7. To provide hands-on experience in solving transportation problems and optimizing task assignments through operations research methods.

Course Outcomes:

CO1: Students will be able to evaluate double and triple integrals to solve real-world problems involving area, volume, and mass.
CO2: Students will be able to calculate work done by force fields and determine flux through surfaces using vector calculus techniques.
CO3: Students will demonstrate a clear understanding of the structure of vector spaces, including basis, dimensions, and subspaces.
CO4: Students will be able to analyze and represent linear transformations through kernel, image, and matrix representation, applying these concepts in practical situations.
CO5: Students will be proficient in finding eigenvalues and eigenvectors, performing diagonalization, and conducting stability analysis in various contexts.
CO6: Students will be able to apply the concepts of orthogonality, projections, and the Gram-Schmidt process to solve problems in inner product spaces.
CO7: Students will be able to model, solve, and optimize linear programming problems, transportation problems, and resource allocation tasks using operations research techniques.

Topics and Learning Points

Teaching Hours

Practical based on Vector Calculus: **20**

1. Exploring area and volume using double integrals
2. Applications of triple integrals in determining mass and volume
3. Evaluating work done by a force field using line integrals
4. Surface integrals and flux calculation in vector fields

Practical based on Linear Algebra: **20**

1. Exploring the structure of vector spaces: Basis, dimensions and subspaces
2. Applications of linear transformations: Kernel, image and matrix representation
3. Eigenvalues and eigenvectors: Diagonalization and stability analysis
4. Inner product spaces: Orthogonality, projections and Gram-Schmidt process

Practical based on Operations Research: **20**

1. Linear programming applications: Modeling and graphical solution technique
2. Optimizing linear programs: A hands-on approach with the simplex method
3. Cost efficiency in logistics: Solving transportation problems
4. Resource optimization in task assignment

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	3	3	3	3	3	3
PO2	2	3	2	3	3	2	3
PO3	1	1	1	1	1	1	3
PO4	2	2	2	3	3	3	3
PO5	3	3	3	3	3	3	3
PO6			2				2
PO7	1	1	2	1	1	1	2
PO8	2	2	3	2	2	2	3
PO9	2	2	2	2	2	2	3
PO10							
PO11							
PO12	2	2	2	2	2	2	3
PO13							

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - Strong correlation across all COs as the course provide a deep understanding of mathematical concepts essential for solving complex problems.
PO2: ***Practical, professional, and procedural knowledge*** - Strong correlation with CO2, CO4, CO5, and CO7 due to the focus on vector calculus, linear transformations, eigenvalues, and operations research.
PO3: ***Entrepreneurial mindset and knowledge*** **-** Weaker correlation except for CO7, where linear programming and optimization are directly relevant to entrepreneurial activities.
PO4: ***Specialized skills and competencies*** - Strong correlation with CO4, CO5, CO6, and CO7, as these outcomes develop advanced mathematical and analytical skills.
PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - Strong correlation with all COs, as each outcome enhances students' problem-solving abilities.
PO6: ***Communication skills and collaboration*** - Moderate correlation with CO3 to CO7, where understanding and communicating complex ideas and collaborating on problem-solving are important.
PO7: ***Research-related skills*** - Moderate correlation, especially in CO3 to CO7, where students develop the skills needed to explore, analyze, and solve research problems.
PO8: ***Learning how to learn skills*** - Strong correlation, particularly in CO3 to CO7, where students continuously develop their understanding and adaptability in mathematical concepts.
PO9: ***Digital and technological skills*** - Moderate correlation with most COs, as mathematical computation often involves digital tools, especially in linear programming and vector calculus.
PO12: ***Autonomy, responsibility, and accountability*** - Moderate correlation, particularly in CO7, where solving and optimizing problems requires autonomous and responsible decision-making.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Minor
Course Name	**:** Multivariable Calculus
Course Code	**:** MAT-261-MN
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To introduce students to vectors, their operations, and their applications in various physical and mathematical contexts.
2. To understand the behavior of vector functions, including their derivatives, integrals, and applications in describing motion in space.
3. To teach students about functions of several variables, including the computation of partial derivatives and their applications.
4. To help students learn the chain rule for multivariable functions and the concept of directional derivatives in various directions.
5. To enable students to compute double and triple integrals and apply them to solve problems in different coordinate systems.
6. To introduce students to essential theorems in vector calculus, including Green's, Stoke's, and the divergence theorems.
7. To equip students with the ability to apply vector calculus concepts to solve physical problems, such as fluid flow and electromagnetic fields.

Course Outcomes:

CO1: Students will be able to perform vector operations, including dot and cross products, and apply them in solving geometric and physical problems.
CO2: Students will demonstrate the ability to work with vector functions, analyze space curves, and calculate their derivatives and integrals.
CO3: Students will be able to compute partial derivatives for functions of several variables and apply them in various contexts, including optimization problems.
CO4: Students will use the chain rule for multivariable functions and compute directional derivatives to analyze rates of change in specific directions.
CO5: Students will be able to evaluate double and triple integrals in Cartesian and other coordinate systems, and apply them to problems involving volume and mass.
CO6: Students will gain an understanding of Green’s theorem, Stoke’s theorem, and the divergence theorem, and apply them to solve integrals in vector fields.
CO7: Students will apply vector calculus techniques to model and solve real-world physical problems, such as fluid dynamics and electromagnetism.

Topics and Learning Points

Topic	Teaching Hours
Unit 1: Vectors and Vector Functions	**08**
1.1 Vectors	
1.2 Dot and cross products	
1.3 Vector functions and space curves	
1.4 Derivatives and integrals of vector functions	
1.5 Arc length and curvature	
1.6 Motion in space: Velocity and acceleration	
Unit 2: Partial Derivatives	**07**
2.1 Functions of several variables	
2.2 Limits and continuity	
2.3 Partial derivatives and the chain rule	
2.4 Directional derivatives	
Unit 3: Multiple Integrals	**07**
3.1 Double integrals	
3.2 Iterated integrals	
3.3 Triple integrals	
Unit 4: Vector Calculus	**08**
4.1 Vector fields	
4.2 Line integrals	
4.3 Green's theorem (without proof)	
4.4 Surface integrals	
4.5 Stoke's theorem (without proof)	
4.6 The divergence theorem (without proof)	

Text Books:

James Stewart, *Calculus with Early Transcendental Functions*, Cengage Learning, Indian Edition

Unit 1: Ch 12 & 13, **Unit 2:** Ch 14,
Unit 3: Ch 15, **Unit 4:** Ch 16.

Reference Books:

1. G. B. Thomas, *Thomas' Calculus*, Pearson, Edition 2012.
2. Tom M. Apostol, *Calculus Vol. II*, John Wiley.
3. Shanti Narayan and R. K. Mittal, *A text-book of Vector Calculus*, S. Chand and Company.
4. J. E. Marsden, A. J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer.
5. D. V. Widder, *Advanced Calculus*, Printice Hall of India.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	3	3	3	3	3	3
PO2	2	2	2	2	3	3	3
PO3	1	1	1	1	1	2	2
PO4	3	3	3	3	3	3	3
PO5	3	3	3	3	3	3	3
PO6	2	2	2	2	2	2	2
PO7	1	1	2	2	2	3	3
PO8	2	2	3	3	3	3	3
PO9			2	2	2	1	1
PO10							
PO11							1
PO12	2	2	2	2	2	2	3
PO13	1	1	1	1	1	1	2

Justification for the mapping

PO1: *Comprehensive knowledge and understanding* - It is strongly related to all COs as the course provides a deep understanding of vector calculus, partial derivatives, and their applications in real-world problems.

PO2: *Practical, professional, and procedural knowledge* - It has a moderate to strong relationship with COs, especially CO5, CO6, and CO7, as these COs involve practical applications of double and triple integrals, and vector calculus theorems in professional contexts.

PO3: *Entrepreneurial mindset and knowledge* – It have a weak relationship, as the course is more focused on technical and analytical skills rather than entrepreneurial knowledge, though some elements of modeling real-world problems (CO6, CO7) could contribute.

PO4: *Specialized skills and competencies* - It is strongly related to all COs as the course imparts specialized mathematical skills required for advanced study in physics, engineering, and other disciplines.

PO5: *Capacity for Application, Problem-Solving, and Analytical Reasoning* - It is directly related to all COs, as the course outcomes focus heavily on solving complex problems using vector calculus and partial derivatives.

PO6: *Communication skills and collaboration* - It is moderately related to all COs, as students will need to explain their reasoning, work in teams, and present their solutions clearly, especially in practical applications.

PO7: *Research-related skills* - It is weakly to moderately related, with a stronger relationship in CO6 and CO7, where students might engage in applying vector calculus to research problems in fluid dynamics or electromagnetism.

PO8: *Learning how to learn skills* - It has a moderate to strong relationship with COs, particularly in mastering new mathematical concepts and applying them in various contexts.

PO9: *Digital and technological skills* - It has a weak to moderate relationship, especially in CO3, CO4, and CO5, where computational tools might be used to solve and visualize problems.

PO11: ***Value inculcation and environmental awareness*** **-** It is weakly related, though CO7 (real-world problem modeling) might involve environmental applications such as fluid dynamics in ecological contexts.
PO12: ***Autonomy, responsibility, and accountability*** - It is moderately to strongly related, especially in CO7, where students must independently apply mathematical concepts to complex problems.
PO13: ***Community engagement and service*** - It has a weak to moderate relationship, particularly where mathematical modeling in CO7 might be applied to community or service projects (e.g., environmental modeling, public infrastructure).

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Minor
Course Name	**:** Practical based on Partial Differential Equations
Course Code	**:** MAT-262-MN
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. Develop a strong foundational understanding of surfaces and curves in three-dimensional space, enabling students to visualize and analyze geometric structures.
2. Equip students with the knowledge and skills to solve simultaneous differential equations in three variables using both analytical and numerical methods.
3. Introduce students to the method of integrating $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$ and guide them through the step-by-step solution process.
4. Enable students to find and plot orthogonal trajectories of curves on a surface, deepening their understanding of differential equations in a geometric context.
5. Provide a thorough introduction to Pfaffian differential forms, focusing on their structure, interpretation, and applications.
6. Teach students advanced techniques for solving Pfaffian differential equations in three variables, with a focus on practical applications.
7. Introduce the genesis and formulation of first-order partial differential equations (PDEs), emphasizing their practical interpretation and application in various fields.

Course Outcomes:

CO1: Students will be able to visualize and analyze surfaces and curves in three dimensions, applying these concepts to solve related problems in physics and engineering.
CO2: Students will demonstrate proficiency in solving simultaneous differential equations in three variables, both analytically and numerically, and interpret their solutions.
CO3: Students will be able to apply the method of integrating $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$ to solve complex differential equations and understand the underlying principles.
CO4: Students will successfully find and plot orthogonal trajectories of a system of curves on a surface, applying this knowledge to real-world problems in engineering and physics.
CO5: Students will gain a deep understanding of Pfaffian differential forms, enabling them to solve related equations and apply these concepts in various mathematical contexts.
CO6: Students will be able to solve Pfaffian differential equations in three variables using advanced techniques, and apply these solutions in practical scenarios.
CO7: Students will be able to formulate first-order partial differential equations, classify integrals, and apply methods such as Charpit's and Jacobi's to construct solutions for given curves, preparing them for advanced studies in mathematical physics and applied mathematics.

Topics and Learning Points

Teaching Hours

List of practical: **60**

1. Exploring Surfaces and Curves in Three Dimensions: Visualization and Analysis
2. Solving Simultaneous Differential Equations in Three Variables: Analytical and Numerical Approaches
3. Method of Integrating $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$: A Step-by-Step Solution
4. Orthogonal Trajectories on a Surface: Finding and Plotting Curves
5. Introduction to Pfaffian Differential Forms: Understanding and Solving
6. Solving Pfaffian Differential Equations in Three Variables: Techniques and Applications
7. Genesis of First Order Partial Differential Equations: Formulation and Interpretation
8. Classification of Integrals in Partial Differential Equations: A Practical Approach
9. Solving Linear Equations of the First Order in PDEs: Methods and Examples
10. Pfaffian Differential Equations in the Context of PDEs: Solution Techniques
11. Application of Charpit's Method in Solving Non-linear First Order PDEs
12. Jacobi's Method and Integral Surfaces: Constructing Solutions for Given Curves

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	3	3	3	3	3	3
PO2	2	3	2	2	3	3	3
PO3							
PO4	2	3	3	3	3	3	3
PO5	3	3	3	3	3	3	3
PO6							
PO7	1	3	3	2	2	2	3
PO8	2	2	2	3	3	3	3
PO9	1	2	2	2	2	2	2
PO10							
PO11							
PO12	2	2	2	3	2	3	3
PO13							

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - All COs strongly contribute to this PO as they involve deep understanding and application of complex mathematical concepts and methods (Rating: 3).
PO2: ***Practical, professional, and procedural knowledge*** - CO2, CO5, CO6, and CO7 have a stronger relation to this PO due to their focus on analytical and procedural skills (Rating: 2 or 3).
PO4: ***Specialized skills and competencies*** - The advanced techniques and applications taught in CO2 through CO7 provide students with specialized skills relevant to mathematics, engineering, and physics (Rating: 2 or 3).
PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - All COs are strongly related to this PO, as they require the application of mathematical principles to solve complex problems (Rating: 3).
PO7: ***Research-related skills*** - CO2, CO3, and CO7 are more closely related due to their involvement in advanced techniques that could be applicable in research contexts (Rating: 2 or 3).
PO8: ***Learning how to learn skills*** - The complexity of the topics and the need to apply advanced mathematical techniques in CO4 through CO7 enhance this PO (Rating: 2 or 3).
PO9: ***Digital and technological skills*** - The use of computational tools and methods, especially in solving differential equations, connects these COs to technological skills (Rating: 1 or 2).
PO12: ***Autonomy, responsibility, and accountability*** - The rigorous nature of the course material, requiring independent study and responsibility in problem-solving, supports this PO, especially in CO4 through CO7 (Rating: 2 or 3).

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Open Elective
Course Name	**:** Applied Mathematics III
Course Code	**:** MAT-266-OE
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To develop the ability to break down any integer into its prime factors, understand the significance of prime factorization in number theory, and apply this knowledge to solve complex mathematical problems.
2. To learn various methods to find the GCD of two or more numbers, understand its applications in simplifying fractions, and use the GCD to solve real-world problems.
3. To gain proficiency in calculating the LCM of integers using different techniques, and apply LCM concepts to solve problems involving scheduling, synchronizing events, and other practical scenarios.
4. To explore the mathematical relationship between GCD and LCM, understand how they interrelate, and apply this knowledge to solve problems involving both concepts.
5. To investigate the properties of various polygons, including triangles and quadrilaterals, and use this understanding to solve problems related to geometry and real-world applications.
6. To learn and apply graphical and algebraic methods to solve systems of linear equations, and develop strategies for solving real-world problems that involve multiple variables.
7. To engage in mathematical puzzles and games to improve logical reasoning, problem-solving skills, and the ability to approach complex problems creatively.

Course Outcomes:

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

CO1: Accurately decompose any integer into its prime factors, explaining the process and significance of prime factorization in various mathematical contexts.

CO2: Proficiently calculate the GCD of multiple numbers using various methods, and apply this knowledge to solve problems such as simplifying fractions and finding common denominators.

CO3: Determine the LCM of integers using different techniques, and apply the LCM in practical scenarios such as scheduling and solving problems involving repetitive events.

CO4: Understand and apply the mathematical relationship between GCD and LCM to solve complex problems, demonstrating how these concepts interrelate and influence each other in various applications.

CO5: Identify and use the properties of polygons, including triangles and quadrilaterals, to solve geometric problems and apply these concepts to real-world scenarios.

CO6: Proficiently solve simultaneous linear equations using both graphical and algebraic methods, and apply these solutions to real-world problems involving multiple variables.

CO7: Develop stronger logical reasoning and problem-solving skills by engaging with mathematical puzzles and games, applying these skills to both theoretical and practical problem-solving scenarios.

Topics and Learning Points

Teaching Hours

List of practical: **60**

1. **Understanding Prime Factorization:** Breaking Down Numbers into Prime Factors.
2. **Finding the Greatest Common Divisor (GCD):** Methods and Applications.
3. **Calculating the Least Common Multiple (LCM):** Techniques and Examples.
4. **Exploring the Relationship Between GCD and LCM**
5. **Exploring Polygons: Properties of Triangles, Quadrilaterals, and More.**
6. **Solving Simultaneous Linear Equations:** Graphical and Algebraic Methods.
7. **Mathematical Puzzles and Games:** Developing Logical Thinking.
8. **Understanding Clock Problems**: Calculating Angles and Time Differences.
9. **Introduction to Polynomials:** Understanding Terms, Degree, and Roots.
10. **Solving Linear Inequalities:** Graphical and Algebraic Methods.
11. **Mental Arithmetic Techniques:** Speed and Accuracy in Basic Calculations.
12. **Developing Numerical Ability:** Solving Word Problems and Estimation.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	3	3	3	3	3	2
PO2	2	3	3	2	2	3	2
PO3	1	1	1	1	1	1	1
PO4	2	3	3	2	3	3	2
PO5	3	3	3	3	3	3	3
PO6	1	1	1	1	1	2	3
PO7	1	1	1	1	1	1	2
PO8	2	2	2	2	2	2	2
PO9	1	1	1	1	1	1	1
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	1	1	1	1	1	1	1
PO13	1	1	1	1	1	1	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - Strongly related to all COs as understanding mathematical concepts is fundamental to gaining comprehensive knowledge.
PO2: ***Practical, professional, and procedural knowledge*** - Strongly linked to CO2, CO3, and CO6 due to their focus on practical applications and procedures; moderate relation with other COs.
PO3: ***Entrepreneurial mindset and knowledge*** - Weakly related as COs are more focused on technical mathematical skills rather than entrepreneurial aspects.
PO4: ***Specialized skills and competencies*** - Strong relation with CO2, CO3, CO5, and CO6, which involve specialized mathematical skills and competencies.
PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - Strongly related to all COs as they involve problem-solving and analytical reasoning.
PO6: ***Communication skills and collaboration*** - Moderately related to CO6 and CO7, which involve presenting solutions and reasoning, but less relevant to others.
PO7: ***Research-related skills*** - Weakly related, with only a moderate relation to CO7, which involves problem-solving skills that can be relevant in research contexts.
PO8: ***Learning how to learn skills*** - Moderately related to all COs as learning mathematical concepts requires self-directed learning.
PO9: ***Digital and technological skills*** - Weakly related as the course does not focus on digital or technological skills.
PO10: ***Multicultural competence, inclusive spirit, and empathy*** - Weakly related as the course focuses on mathematical skills rather than multicultural competence.
PO11: ***Value inculcation and environmental awareness*** - Weakly related as the course is primarily focused on technical mathematics.
PO12: ***Autonomy, responsibility, and accountability*** - Weakly related as the course content does not emphasize these aspects directly.
PO13: ***Community engagement and service*** - Weakly related with only CO7 showing some relevance in developing skills applicable to community engagement.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2023 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** IV
Course Type	**:** Skill Enhancement Course
Course Name	**:** GeoGebra Software
Course Code	**:** MAT-276-SEC
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To enable students to perform and understand basic geometric constructions such as bisectors, perpendiculars, and circles using GeoGebra.
2. To help students visualize and analyze geometric transformations including translations, rotations, reflections, and dilations.
3. To provide students with the skills to graph linear equations, inequalities, and quadratic functions, enhancing their comprehension of algebraic solutions and their graphical representations.
4. To facilitate the exploration of conic sections and the properties of circles, helping students gain insights into the underlying geometric principles.
5. To assist students in visualizing the unit circle and trigonometric functions, promoting a deeper understanding of their relationships and applications.
6. To train students in solving systems of linear equations graphically and understanding the geometric interpretations of vectors.
7. To provide an introduction to limits, continuity, and derivatives using graphical analysis, making abstract concepts more concrete and understandable.

Course Outcomes:

CO1: Students will be able to accurately construct geometric figures such as bisectors, perpendiculars, and circles, and understand their properties.
CO2: Students will gain proficiency in visualizing and executing geometric transformations, and understanding their effects on figures.
CO3: Students will be able to graph linear equations, inequalities, and quadratic functions, interpreting solutions through graphical analysis.
CO4: Students will demonstrate the ability to analyze and explore the properties of conic sections and circles, including tangents, chords, and arcs.
CO5: Students will understand and apply the concepts of the unit circle and trigonometric functions in various mathematical contexts.
CO6: Students will be able to solve systems of linear equations and perform vector operations using graphical methods, interpreting the results geometrically.
CO7: Students will develop a foundational understanding of limits, continuity, and derivatives, using graphical analysis to visualize and solve related problems.

Topics and Learning Points

Teaching Hours

List of practical: **60**

1. **Exploring basic geometric constructions:** *Bisector, perpendicular and circles* -
   Learn to construct basic geometric objects like angle bisector, perpendicular lines and circles.
2. **Visualizing and analyzing transformations:** *Translations, rotations, reflections and dilations* -
   Experiment with different geometric transformations and their effects on shapes.
3. **Graphing linear equations and inequalities:** *Visual understanding of solutions* -
   Plot and analyze linear equations and inequalities, focusing on their graphical interpretations.
4. **Understanding the slope and intercept of a line:** *Interactive exploration* -
   Investigate how changes in slope and intercept affect the graph of a linear equation.
5. **Exploring quadratic functions:** *Graphs, vertex and roots* -
   Visualize the effect of coefficients on the shape of a parabola and find the vertex and roots.
6. **Investigating the properties of circles:** *Tangents, chords and arcs* -
   Use GeoGebra to explore properties of circles, including the relationship between tangents, chords and arcs.
7. **Visualizing conic sections:** *Ellipses, hyperbolas and parabolas* -
   Analyze the geometric properties and equations of conic sections.
8. **Exploring the unit circle and trigonometric functions** -
   Use the unit circle to understand the relationship between angles and trigonometric functions.
9. **Solving system of linear equations graphically** -
   Plot system of linear equations and find their intersection points as solutions.
10. **Introduction to vectors:** *Operations and geometric interpretations* -
    Work with vectors in two dimensions, exploring operations such as addition, subtraction and scalar multiplication.
11. **Understanding limits and continuity through graphical analysis** -
    Use Geogebra to visualize the concept of limits and explore the continuity of functions graphically.
12. **Introduction to derivatives:** *Tangent lines and rates of change* -
    Investigate the derivative of a function as the slope of the tangent line and explore its interpretation as a rate of change.

CO-PO Mapping

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO1	3	3	3	3	3	3	3
PO2	3	3	3	3	3	3	3
PO3			2			2	
PO4	3	3	3	3	3	3	3
PO5	3	3	3	3	3	3	3
PO6							
PO7	1	1	2	2	2	2	2
PO8	2	2	2	2	2	2	3
PO9	3	3	3	3	3	3	3
PO10							
PO11							
PO12	2	2	2	2	2	2	2
PO13							

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - All COs are strongly linked as they cover fundamental concepts and hands-on practice in geometry, algebra, and calculus, critical to mastering mathematical principles.
PO2: ***Practical, professional, and procedural knowledge*** - All COs are strongly linked as they cover fundamental concepts and hands-on practice in geometry, algebra, and calculus, critical to mastering mathematical principles.
PO3: ***Entrepreneurial mindset and knowledge*** - Moderate relation with CO3 and CO6 as they involve problem-solving and application skills that can translate into practical, innovative solutions, although entrepreneurship is not the main focus.
PO4: ***Specialized skills and competencies*** - Strong relation to all COs, particularly in developing specific mathematical competencies, such as geometric construction (CO1), transformations (CO2), and calculus (CO7).
PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - Strongly related to all COs, as the course emphasizes solving mathematical problems through analysis and reasoning.
PO7: ***Research-related skills*** - Weak to moderate relation, as some COs (e.g., CO3, CO4) involve exploration and discovery, which can cultivate research skills, though this is not the course's main emphasis.
PO8: ***Learning how to learn skills*** - Moderate to strong relation, especially CO7, where students learn complex topics like limits and derivatives, encouraging independent learning and critical thinking.
PO9: ***Digital and technological skills*** - Strong relation to all COs, given the use of tools like GeoGebra and other software to visualize and solve mathematical problems.
PO12: ***Autonomy, responsibility, and accountability*** - Moderate relation, as students must take responsibility for their learning, complete assignments independently, and manage their progress.