Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(Autonomous)

Department of Mathematics

2019 Pattern

S. Y. B. Sc. (Mathematics)

Semester	Course Code	Title of Course	No. of Credits	No. of Lectures
III	MAT 2301	Multivariable Calculus - I	3	48
	MAT 2302	Laplace Transform & Fourier Series	3	48
	MAT 2303	Practical based on MAT 2301 and MAT 2302	2	48
IV	MAT 2401	Linear Algebra	3	48
	MAT 2402	Multivariable Calculus - II	3	48
	MAT 2403	Practical based on MAT 2401 and MAT 2402	2	48

Choice Based Credit System Syllabus (2019 Pattern)

Class: S.Y.B.Sc. (Semester – IV)
Course Code: MAT 2401
Course: 1 **Title of the Course:** Linear algebra
Credit: 3 **No. of Lectures:** 48

A) Course Objectives:

1. To understand the concepts of Vector space, linear transformation, Inner Product.
2. To understand algebraic and geometric representations of vectors $\mathbb{R}^n$ and their operations, including addition, scalar multiplication and dot product.
3. To find the null space of a matrix and span of independent vectors.
4. To find basis and dimensions of finite dimensional Vector Spaces.
5. To find the matrix of a linear transformation given bases of relevant vector spaces.
6. To learn Inner product spaces and determine orthogonality in Inner product spaces.
7. To apply this knowledge to various fields in engineering, statistics and computer science.

B) Course Outcomes:

1. Students will able to understand the concepts of Vector space, linear transformation, Inner Product.
2. Students will able to understand algebraic and geometric representations of vectors $\mathbb{R}^n$ and their operations, including addition, scalar multiplication and dot product.
3. Students will able to find the null space of a matrix and span of independent vectors.
4. Students will able to find basis and dimensions of finite dimensional Vector Spaces.
5. Students will able to find the matrix of a linear transformation given bases of relevant vector spaces.
6. Students will able to learn Inner product spaces and determine orthogonality in Inner product spaces.
7. Students will able to apply this knowledge to various fields in engineering, statistics and computer science.

TOPICS/ CONTENT:

Unit 01: Vector Spaces [14 lectures]

- Definitions and Examples.
- Vector Subspaces.
- Linear Independence.
- Basis and Dimensions of a Vector Space.
- Row and Column Spaces of a matrix.
- Row rank and Column rank.

Unit 02: Linear Transformations [12 lectures]

- Linear Transformation, representation by a matrix.
- Kernel and Image of a Linear Transformation.
- Rank-Nullity theorem.
- Linear Isomorphism.
- L (V, W) is a vector space. Dimension of L(V,W) (Statement only)

Unit 03: Inner Product spaces: [16 lectures]

- The Euclidean space and dot product.
- General inner product spaces.
- Orthogonality, Orthogonal projection onto a line, Orthogonal basis.
- Gram-Schmidt Orthogonalization.
- Orthogonal Transformation.

Unit 04: Eigen values and Eigen vectors: [6 lectures]

- Rotation of axes of conics.
- Eigenvalues and eigenvectors.

Text Book:

S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India, New Delhi, Chapters: 2, 4, 5 (excluding Arts 4.4.10 -4.4.12, 5.3. 5.6, 5.7, 5.9), 7.1, 7.2.

Reference Books:

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

Mapping of Program Outcomes with Course Outcomes

Class: SYBSc (Sem IV) **Subject:** Mathematics
Course: Linear algebra **Course Code:** MAT 2401
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3		2		2			2
CO 2	3	3				2			2
CO 3	3	3				2			2
CO 4	3	3		2	3	2			2
CO 5	3	3		2		2			2
CO 6	3	3				2			2
CO 7	3	3		2	1	2			2

Justification for the mapping

PO 1: Disciplinary Knowledge:

All of these course outcomes (COs) contribute to the development of student's disciplinary knowledge in mathematics. For example, CO1, CO2, CO3, CO5, CO6 requires student to develop

deep learning of vector spaces, linear transformation, inner product spaces. CO4 requires students to apply the concepts of linear algebra in many fields like engineering, statistics and computer science.

PO2: Critical Thinking and Problem Solving:

All of these course outcomes (COs) contribute to the development of students critical thinking and problem solving. For example, CO1, CO2 CO3, CO5 requires students to think critically and apply these to solve complex problems in various filed like engineering and physics. CO4, CO6 and CO7 requires to apply and construct logical proofs to solve real world problems.

PO4: Research-related skills and Scientific temper:

CO1, CO4, CO5, CO7 contribute to the development of student's research related skills and scientific temper. For example, CO4 and CO7 requires students to develop their ability to think critically and apply knowledge to various field. CO1 and CO5 requires students to apply knowledge of system of linear equations and inner product spaces and apply to solve real world problem.

PO5: Trans-disciplinary Knowledge:

CO4, CO7 requires students to apply linear algebra tools in various fields like Physics, Engineering and Computer science.

PO6: Personal and professional competence:

All COs contribute to development of personal and professional competences. For example, all COs requires students to approach and solve complex problem systematically.

PO9: Self-directed and Life-long learning:

All these course outcomes contribute to development of student's ability to engage in self-directed and life-long learning. For example, all COs requires students to develop their ability to learn new concepts, form a simple proof and apply them to new problem.

Choice Based Credit System Syllabus (2019 Pattern)

Class: S.Y.B.Sc. (Semester – IV)
Course Code: MAT 2402
Course: 2 **Title of the Course:** Multivariable Calculus II
Credit: 3 **No. of Lectures:** 48

A) Course Objectives:

1. To develop a solid understanding of double integrals over rectangles, including the techniques for evaluating them and their geometric interpretations.
2. To explore the concept of iterated integrals, enabling students to decompose complex regions and integrate over them using both the horizontal and vertical orders of integration.
3. To extend the knowledge to double integrals over general regions, allowing students to apply various coordinate transformations and choose appropriate integration bounds for non-rectangular domains.
4. Develop a deep understanding of triple integrals, enabling students to calculate volumes, masses, and other quantities in three-dimensional space.
5. Attain proficiency in utilizing cylindrical and spherical coordinates to simplify and solve complex integration problems, expanding the scope of applications in three-dimensional calculus.
6. Understand the fundamental concepts and properties of vector fields, including vector operations, divergence, curl, and the interpretation of vector fields in physical contexts.
7. Develop proficiency in computing line integrals, applying various techniques to evaluate path-dependent quantities in vector fields, and interpreting their significance in real-world applications.
8. Develop a solid comprehension of the concepts of curl and divergence in vector fields.
9. Learn methods for computing surface areas of parametric surfaces and apply them in diverse contexts.
10. Understand the principles of Stoke's theorem and the divergence theorem, and be able to apply them to evaluate line integrals, flux, and volume integrals.

B) Course Outcomes:

1. Students will be able to compute double integrals over rectangles, demonstrating proficiency in setting up and evaluating integrals in Cartesian coordinates for various functions and geometric regions.
2. Students will have the capability to apply polar coordinates for double integrals, enabling them to analyze and evaluate functions in circular and sectorial regions, and understand the advantages of this coordinate system in certain scenarios.
3. Students will be able to set up and evaluate triple integrals over general regions in Cartesian, cylindrical, and spherical coordinates, demonstrating proficiency in solving problems related to volume, mass, and other physical quantities.
4. Students will demonstrate the ability to seamlessly transition between Cartesian, cylindrical, and spherical coordinate systems, selecting the most appropriate system for a given problem. They will apply these skills to solve a range of real-world problems, including those involving irregularly shaped objects and regions.

5. Students will be able to analyze and manipulate vector fields, demonstrating a solid grasp of vector operations, divergence, and curl, and their respective applications in physics and engineering.
6. Upon completion of the course, students will be capable of effectively utilizing line integrals to calculate quantities such as work, circulation, and flux, and will understand the geometric interpretations and practical implications of these computations.
7. Students will be able to identify and calculate curl and divergence for various vector fields, enabling them to analyze the behavior of physical systems governed by these vector fields.
8. Students will demonstrate proficiency in computing areas of parametric surfaces and will be able to apply Stoke's theorem and the divergence theorem to solve problems related to flux, circulation, and volume integrals.

TOPICS/ CONTENT:

Unit 01: Line Integral [16 lectures]

- Introduction, Paths and line integrals
- Other notations for line integrals, Basic properties of line integrals
- The concept of work as a line integral, Line integral with respect to arc length
- Further applications of line integrals
- Open connected sets. Independence of the path
- The second fundamental theorem of calculus for line integral
- The first fundamental theorem of calculus for line integral
- Necessary and sufficient condition for a vector field to be a gradient

Unit 02: Multiple Integrals [16 lectures]

- Introduction, Partitions of rectangles, step functions
- The double integral of a step function
- The definition of the double integral of a function defined and bounded on a rectangle, Upper and lower double integrals
- Evaluation of a double integral by repeated one dimensional integration
- Geometrical interpretation of the double integral as a volume
- Integrability of continuous functions, Integrability of bounded functions with discontinuities, Double integral extended over more general regions
- Applications to area and volume, Green's theorem in the plane
- Green's theorem for multiply connected regions

Unit 03: Surface Integrals [16 lectures]

- Parametric representation of a surface, The fundamental vector product
- The fundamental vector product as a normal to the surface
- Area of a parametric surface, Surface integrals
- Change of parametric representation, other notations for surface integrals
- The theorem of Stokes, The curl and divergence of a vector field
- Further properties of the curl and divergence, Reconstruction of a vector field from its curl, The Gauss divergence theorem (without proof)

Text Book:

Tom M. Apostol, Calculus Vol. II, John Wiley, New York (Second Edition)
Chapters: 10, 11 and 12

Reference Books:

1) G. B. Thomas, Thomas' Calculus, Pearson Edition 2012.

2) Basic Multivariable Calculus, J. E. Marsden, A. J. Tromba, A. Weinstein, Springer
3) Shanti Narayan, R.K. Mittal, A Text-book of Vector Calculus, S. Chand and Company.
4) D.V. Widder, Advanced Calculus (2nd Edition), Prentice Hall of India, New Delhi.

Mapping of Program Outcomes with Course Outcomes

Class: SYBSc (Sem IV) **Subject:** Mathematics
Course: Multivariable Calculus II **Course Code:** MAT 2402
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	3							
CO 2	3	3			1			1	
CO 3	3	3		1	1			1	
CO 4	3	2							
CO 5	3	3							
CO 6	3	3							
CO 7	3	3							
CO 8	3	3							

Justification for the mapping

PO1: Disciplinary Knowledge
CO1: Student will demonstrate proficiency in setting up and evaluating double integrals over rectangles in Cartesian coordinates, showcasing their ability to apply disciplinary knowledge to compute areas and volumes for various functions and geometric regions.
CO2: Mastering polar coordinates for double integrals equips student to proficiently analyze circular and sectorial regions, providing a powerful tool for mathematical modeling and problem-solving in diverse scientific and engineering fields.
CO3: Student will gain the ability to apply advanced mathematical techniques in Cartesian, cylindrical, and spherical coordinates to solve real-world problems involving volume, mass, and other physical quantities, showcasing their mastery of Disciplinary Knowledge.
CO4: Student will master diverse coordinate systems, facilitating informed choices between Cartesian, cylindrical, and spherical systems for efficient problem-solving, particularly in real-world scenarios with complex geometries, enhancing their disciplinary knowledge.
CO5: Student will acquire a proficient understanding of vector operations, divergence, and curl, enabling them to effectively analyze and manipulate vector fields for practical applications in physics and engineering disciplines.
CO6: Student will master line integrals, grasping both their geometric significance and practical utility across disciplines, by engaging in rigorous mathematical coursework that equips them to calculate work, circulation, and flux with precision.
CO7: Student can identify and calculate curl and divergence for vector fields, facilitating the analysis of physical systems by providing insights into their rotational and divergent properties.
CO8: Mastering parametric surfaces, Stoke's theorem, and the divergence theorem equips student with the tools to effectively analyze flux, circulation, and volume integrals, enhancing their grasp of advanced vector calculus concepts within disciplinary knowledge.

PO2: Critical Thinking and Problem Solving
CO1: Student will develop the ability to apply critical thinking and problem-solving skills in computing double integrals over rectangles, demonstrating proficiency in setting up and

evaluating integrals in Cartesian coordinates for diverse functions and geometric regions, enhancing their mathematical problem-solving capabilities.
CO2: Student will acquire the ability to apply polar coordinates for double integrals, facilitating the analysis and evaluation of functions in circular and sectorial regions, thereby enhancing their problem-solving skills by harnessing the advantages of this coordinate system in scenarios that exhibit radial symmetry.
CO3: Student will develop a versatile mathematical skillset, enabling them to efficiently analyze complex three-dimensional geometries and apply integral calculus to solve real-world problems involving volume, mass, and other physical quantities.
CO4: Student will master coordinate system transitions to tackle real-world problems effectively by choosing the most suitable system, enhancing their critical thinking and problem-solving abilities.
CO5: Studying vector fields enhances critical thinking and problem-solving skills by enabling student to proficiently analyze and manipulate vector operations, divergence, and curl, essential for tackling complex problems in physics and engineering.
CO6: Studying line integrals enhances students' analytical thinking by providing them with a powerful mathematical tool to quantify and understand physical phenomena, such as work, circulation, and flux, allowing for deeper insight into real-world applications and geometric interpretations.
CO7: Studying curl and divergence equips student with essential tools to analyze and understand the dynamic behavior of vector fields, enhancing their critical thinking and problem-solving abilities in the realm of physical systems.
CO8: Student will demonstrate proficiency in computing areas of parametric surfaces and applying Stoke's theorem and the divergence theorem to solve problems related to flux, circulation, and volume integrals in order to develop advanced problem-solving skills essential for real-world applications in various fields.

PO4: Research-related skills and Scientific temper
CO3: Mastering triple integrals in diverse coordinates enhances precision in complex geometry analysis, enabling accurate calculations of volume, mass, and crucial physical properties for research, nurturing a robust scientific mindset.

PO5: Trans-disciplinary Knowledge
CO2: Mastering polar coordinates for double integrals empowers student to proficiently analyze functions in circular and sectorial regions, providing a versatile tool applicable across various disciplines for more efficient problem-solving and analysis.
CO3: Student will acquire the ability to apply triple integrals in various coordinate systems, enabling them to analyze complex regions and calculate volume, mass, and diverse physical properties across disciplines.

PO8: Environment and Sustainability
CO2: Proficiency in applying polar coordinates for double integrals empowers student to effectively analyze and evaluate functions in circular and sectorial regions, providing a crucial tool for addressing environmental and sustainability challenges that often exhibit inherent rotational symmetry.
CO3: Proficiency in setting up and evaluating triple integrals in various coordinate systems enables student to accurately analyze and quantify volume, mass, and other essential physical parameters, facilitating informed decision-making for environmental and sustainability concerns.

Choice Based Credit System Syllabus (2019 Pattern)

Class: S.Y.B.Sc. (Semester – IV)
Course Code: MAT 2403
Course: 3 **Title of the Course:** Practical based on MAT 2401 & MAT 2402
Credit: 2 **No. of Lectures:** 48

A) Course Objectives:

1. To understand the concepts of Vector space, linear transformation, Inner Product.
2. To find the null space of a matrix and span of independent vectors.
3. To find the matrix of a linear transformation given bases of relevant vector spaces.
4. To apply this knowledge to various fields in engineering, statistics and computer science.
5. To develop a solid understanding of double integrals over rectangles, including the techniques for evaluating them and their geometric interpretations.
6. To attain proficiency in utilizing cylindrical and spherical coordinates to simplify and solve complex integration problems, expanding the scope of applications in three-dimensional calculus.
7. To learn methods for computing surface areas of parametric surfaces and apply them in diverse contexts.

B) Course Outcomes:

1. Students will able to understand the concepts of Vector space, linear transformation, Inner Product.
2. Students will able to find the null space of a matrix and span of independent vectors.
3. Students will able to find the matrix of a linear transformation given bases of relevant vector spaces.
4. Students will able to apply this knowledge to various fields in engineering, statistics and computer science.
5. Students will be able to compute double integrals over rectangles, demonstrating proficiency in setting up and evaluating integrals in Cartesian coordinates for various functions and geometric regions.
6. Students will be able to analyze and manipulate vector fields, demonstrating a solid grasp of vector operations, divergence, and curl, and their respective applications in physics and engineering.
7. Students will be able to identify and calculate curl and divergence for various vector fields, enabling them to analyze the behavior of physical systems governed by these vector fields.

Title of experiments:
Linear Algebra

- Vector Spaces I
- Vector Space II
- Linear Transformation
- Inner Product Spaces
- Eigenvalues and Eigenvectors
- Numerical Analysis methods II
- Use of software to study Linear Algebra

Multivariable Calculus II

- Line Integral
- Multiple Integral
- Greens Theorem
- Surface Integral
- Stokes Theorem and Divergence Theorem
- Numerical Analysis Problems II
- Use of software to study Multivariable Calculus II

Mapping of Program Outcomes with Course Outcomes

Class: SYBSc (Sem IV) **Subject:** Mathematics
Course: Practical based on MAT 2401 & MAT 2402 **Course Code:** MAT 2403
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3= strong or direct relation.

	Programme Outcomes (POs)								
Course Outcomes	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	2							
CO 2	3	2		2	2				
CO 3	3	2		2					
CO 4	3	2							
CO 5	3			2					
CO 6	3	2		2					
CO 7	3			2	2	2			2

Justification for the mapping

PO 1: Disciplinary Knowledge:
All of these COs contribute to development of student's disciplinary knowledge. For example, CO1, CO2, CO3 requires to think students critically to apply differentiation, behaviour of functions in various fields. CO5, CO6 and CO7 requires to develop deep understanding of continuity, limits of a function, differentiation and use it to solve real world problems.

PO2: Critical Thinking and Problem Solving:
CO1, CO2 and CO4 requires to development of student's knowledge of derivative, Mean Value theorems, integration to find critical points of a function, to solve problems related to accuracy etc. CO3, CO6 contribute to development of students understanding to solve real world problems in different fields by using behaviour of functions.

PO4: Research-related skills and Scientific temper:
CO2, CO3, CO5, CO6, CO7 requires to develop students research related skills. Student's will able to apply the tools of calculus to various real-world problems in different areas.

PO5: Trans-disciplinary Knowledge:
CO7: Students will apply mathematical concept such as Continuity, limits and differentiation. These concepts are useful in many different fields such as Physics, engineering, chemistry and economics.

PO6: Personal and professional competence:
CO7 requires to demonstrate the student's ability to apply mathematical concept such as continuity and derivative in practical manner. This ability is essential for personal and professional development.

PO9: Self-directed and Life-long learning:

CO7: Students will demonstrate the ability to apply the concept of calculus and differential equations in practical context. This ability will enable them to continue learning and developing skills throughout life.