Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science & Commerce, Baramati

(*Empowered Autonomous*)

Three/Four Year Honours/Honours with Research B.Sc. (Comp. Sci.) Degree Program

(Faculty of Science)

CBCS Syllabus

T.Y.B.Sc. (Comp. Sci.) Mathematics

For Department of Mathematics

NEP-1.0

Choice Based Credit System Syllabus

(2023 Pattern)

(As Per NEP-2020)

To be implemented from Academic Year 2025-26

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

Name of the Programme	**:** B.Sc. (Comp. Sci.) Mathematics
Program Code	**:** USCS
Class	**:** T.Y.B.Sc. (Comp. Sci.)
Semester	**:** V
Course Type	**:** Minor
Course Name	**:** Linear Algebra
Course Code	**:** COS-311-MN(B)
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To understand properties and operations on System of Linear Equations.
2. To understand basic concepts of Determinants.
3. Understanding of how to translate a linear equation into a matrix.
4. Identify and analyse properties of vector spaces.
5. Understand the concepts of basis and dimensions in vector spaces.
6. Construct orthogonal bases using the Gram-Schmidt process.
7. Understand the use of eigenvalues and eigenvectors with complex matrices.

Course Outcomes:

CO1: Student will apply the principles of Euclidean n-space, including geometric interpretations and applications.
CO2: Recognize and apply the concept of linear independence in vector spaces.
CO3: Analyse and understand the row space, column space, and null space of matrices, and relate them to linear transformations.
CO4: Apply techniques for determining eigenvalues and eigenvectors of matrices.
CO5: Apply the concept of inverse linear transformations and recognize their importance in various applications.
CO6: Analyse and calculate the kernel and range of linear transformations.
CO7: Apply inner products to analyse angles and Orthogonality in inner product spaces.

Topics and Learning Points

	Teaching Hours
Unit 1: Vector Spaces	**10**
1.1 Vector Spaces and Subspaces	
1.2 Solving $Ax = 0$ and $Ax = b$	
1.3 Linearly Independence, Basis and Dimensions	
1.4 Linear Transformations	
Unit 2: Orthogonality	**07**
2.1 Orthogonal Vectors and subspaces	
2.2 Orthogonal Bases	
2.3 Gram-Schmidt	
Unit 3: Eigen Values and Eigen Vectors	**07**
3.1 Introduction	
3.2 Diagonalization of a Matrix	
3.3 Difference Equations and Powers Ak	
3.4 Complex Matrices	
Unit 4: Symmetric Matrices	**06**
4.1 Diagonalization of Symmetric Matrices	
4.2 Quadratic Forms	

Text Books:

1. Gilbert Strang, *Linear Algebra and its applications*, Cengage Learning, 4th Edition.
   Unit 1: Section 2.1 to 2.4
   Unit 2: Section 3.1 and 3.4
   Unit 3: Section 5.1 to 5.3 and 5.5
2. David C. Lay, *Linear Algebra and its Applications*, MacDonald Pearson Publication, 4th Edition.
   Unit 4: Section 7.1, 7.2

Reference Books:

1. Kanti Bhushan Datta, *Matrix and Linear Algebra* (*aided with MATLAB*), Eastern Economic Edition.
2. Devi Prasad, *Elementary Linear Algebra*, Narosa, 3rd Edition.
3. Sheldon Axler, *Linear Algebra Done Right*, Springer, 2nd Edition.
4. S. Kumaresan, *Linear Algebra: A Geometric Approach*, Prentice Hall of India, New Delhi.
5. K. Hoffmann and R. Kunze, *Linear Algebra*, Prentice 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
PO01	3	3	3	3	3	3	3
PO02	2	2	3	3	3	3	3
PO03	1	1	1	2	2	2	1
PO04	2	2	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	1	1	2	2	2	2	2
PO07	1	2	2	2	2	2	2
PO08	2	2	2	2	2	2	2
PO09	1	1	2	2	2	2	2
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	1	2	2	2	2	2	2
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - All COs deal with foundational and advanced topics in linear algebra and vector spaces. Students gain deep conceptual clarity and comprehensive understanding of Euclidean spaces, vector spaces, transformations, and inner product spaces.

PO2: ***Practical, professional, and procedural knowledge*** - Students apply procedural skills such as computing eigenvalues, null spaces, kernels, and inner products. These are essential for applications in computer science, physics, engineering, and data analysis.

PO3: ***Entrepreneurial mindset and knowledge*** **-** While the course is theoretical, it nurtures problem-solving strategies and abstract reasoning, which can support entrepreneurial thinking in tech-related fields.

PO4: ***Specialized skills and competencies*** - Students acquire specialized mathematical tools and methods applicable to research, engineering, data science, etc.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - Each CO involves deep problem-solving, analytical reasoning, and structured thinking essential in linear algebra and its applications.

PO6: ***Communication skills and collaboration*** - Though not a communication-based course, students often work on problems collaboratively and may present solutions in classroom settings.

PO7: ***Research-related skills*** - Understanding linear transformations, kernels, and orthogonality builds foundational skills for higher-level mathematical research and theoretical computer science.

PO8: ***Learning how to learn skills*** - The course builds critical abstraction and self-learning skills necessary for future study and independent learning.

PO9: ***Digital and technological skills*** - Indirect application through software (e.g., MATLAB, Python with NumPy) to perform computations involving transformations and vector spaces.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - This outcome is not directly targeted by this course.

PO11: ***Value inculcation and environmental awareness*** - Course does not address value or environmental components directly.

PO12: ***Autonomy, responsibility, and accountability*** - Students learn to take responsibility for solving complex problems independently and managing their learning in an abstract domain.
PO13: ***Community engagement and service*** - No direct focus, though the abstract thinking developed may support problem-solving in community-oriented technologies.

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

Name of the Programme	**:** B.Sc. (Comp. Sci.) Mathematics
Program Code	**:** USCS
Class	**:** T.Y.B.Sc.(Comp.Sci.)
Semester	**:** V
Course Type	**:** Minor
Course Name	**:** Linear Algebra Practical using GeoGebra software
Course Code	**:** COS-312-MN(B)
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To represent and explore vector spaces and subspaces geometrically in 2D and 3D using GeoGebra.
2. To solve and visualize homogeneous and non-homogeneous linear systems using GeoGebra.
3. To graphically verify linear independence and determine vector space dimensions.
4. To visualize and understand the geometric effects of linear transformations.
5. To compute and visualize orthogonal vectors, subspaces, and projections using GeoGebra.
6. To apply and visualize the Gram-Schmidt process for orthogonalization.
7. To compute, visualize, and interpret eigenvalues, eigenvectors, and diagonalization of matrices.

Course Outcomes:

CO1: Student will be able to visually represent vector spaces and subspaces in both 2D and 3D, enhancing their understanding of the geometric structure and properties of vector spaces.

CO2: Student will acquire the ability to solve both homogeneous and non-homogeneous linear systems and interpret their solutions geometrically using GeoGebra.

CO3: Students will be able to graphically assess the linear independence of vectors and determine the dimension of vector spaces, strengthening their conceptual understanding of these fundamental linear algebra concepts.

CO4: Students will demonstrate the ability to analyse and explore the properties of conic sections and circles, including tangents, chords, and arcs.

CO5: Students will gain the skills to compute and visualize orthogonal vectors and subspaces, and use dot products and projections to explore orthogonality in vector spaces.

CO6: Students will become proficient in performing the Gram-Schmidt orthogonalization process on a set of vectors and visualizing the results, helping them understand the construction of orthogonal bases.

CO7: Students will be able to compute, visualize, and interpret eigenvalues and eigenvectors, and apply matrix diagonalization techniques, including working with symmetric and complex matrices, using GeoGebra to reinforce their theoretical knowledge through practical visualization.

Topics and Learning Points

Teaching Hours

List of Practical's: 60

1. Explore vector spaces and subspaces in 2D/3D and represent them geometrically.
2. Use GeoGebra to solve and visualize the solutions to these linear systems.
3. Graphically check if a set of vectors is linearly independent and determine the dimension of a vector space.
4. Visualize the effects of linear transformations on geometric shapes or vectors in GeoGebra.
5. Use GeoGebra to visualize and calculate orthogonal vectors and subspaces, exploring dot products and projections.
6. Generate and visualize orthogonal bases in 2D/3D vector spaces using GeoGebra.
7. Perform and visualize the Gram-Schmidt orthogonalization process in GeoGebra on a set of vectors.
8. Use GeoGebra to compute and visualize the eigenvalues and eigenvectors of a matrix.
9. Demonstrate and visualize the diagonalization process of a matrix in GeoGebra.
10. Explore and visualize eigenvalues, eigenvectors, and transformations for complex matrices.
11. Use GeoGebra to perform diagonalization on symmetric matrices and visualize the eigenvalues and eigenvectors.

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
PO01	3	3	3	3	3	3	3
PO02	2	3	3	2	3	3	3
PO03	1	1	2	1	1	1	2
PO04	2	3	3	2	3	3	3
PO05	2	3	3	3	3	3	3
PO06	1	2	2	2	2	2	2
PO07	1	2	2	1	2	2	2
PO08	2	2	2	2	2	2	2
PO09	2	3	3	2	3	3	3
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	1	2	2	1	2	2	2
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: *Comprehensive knowledge and understanding* - All COs (CO1 to CO7) emphasize theoretical understanding of vector spaces, orthogonality, eigenvalues, and linear systems. These are core concepts in linear algebra, justifying strong alignment with comprehensive knowledge.

PO2: *Practical, professional, and procedural knowledge* - Use of GeoGebra and other visual tools for solving and interpreting problems (e.g., CO2, CO3, CO5, CO6, CO7) demonstrates practical application. Hence, higher weightage is given, especially for CO2 and CO7.

PO3: *Entrepreneurial mindset and knowledge* - While the course provides tools that may support entrepreneurship indirectly (e.g., problem-solving, visualization), it does not directly focus on entrepreneurship. Thus, the mapping is weak to moderate, especially for CO3 and CO7.

PO4: *Specialized skills and competencies* - Skills such as orthogonalization (CO6), eigenvalue computations (CO7), and graphical interpretations (CO2, CO3) involve specialized competencies that go beyond basic theory, justifying a strong relation for most COs.

PO5: *Capacity for Application, Problem-Solving, and Analytical Reasoning* - All COs involve strong analytical reasoning, whether in solving systems (CO2), analyzing geometry (CO4), or interpreting transformations (CO7), hence strong mapping across the board.

PO6: *Communication skills and collaboration* - Moderate mapping is considered since some COs may involve collaborative exploration and presentations (especially CO2, CO3, CO4) in a lab or project-based learning environment using tools like GeoGebra.

PO7: *Research-related skills* - While not focused on research per se, the course outcomes (especially CO3, CO5, CO6, CO7) encourage exploration, visualization, and critical thinking which are foundational to research abilities.

PO8: *Learning how to learn skills* - The course promotes independent and visual learning through technology, helping students understand abstract concepts practically, aligning moderately across COs.

PO9: *Digital and technological skills* - A strong relationship is present due to the integration of GeoGebra and visual computational techniques across multiple COs, notably CO2, CO5, CO6, and CO7.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - The course is content-focused and does not explicitly address multiculturalism or empathy, resulting in a weak mapping.
PO11: ***Value inculcation and environmental awareness*** - Similar to PO10, the course does not explicitly include values or environmental themes. Thus, the alignment is weak.
PO12: ***Autonomy, responsibility, and accountability*** - Students working independently with mathematical tools and assignments are moderately developing autonomy (e.g., CO2, CO5, CO6, CO7), hence a medium mapping for relevant COs.
PO13: ***Community engagement and service*** - This course does not directly engage with community or service-related outcomes, so the alignment is weak for all COs.