FYUGP Mathematical Sciences (Batch 2024 and Onwards)

FYUGP Mathematical Sciences Course Outline for Semester III (Batch 2024)

S. No.	Category	Course Code	Course Title	Credits	L	T	P	S	Hours per week
1	Major	MTHS202MJ	Real Analysis	4	4	x	x	x	4
		MTHS203MJ	Applied Linear Algebra	4	3	x	2	x	5
2	Minor 3		Students to choose	4					
4	Multidisciplinary		Student to choose	3	3	x	x	x	3
5	Ability Enhancement			3	3	x	x	x	3
6	Skill Enhancement		Student to choose	2	3	x	x	x	3

Course Title: Real Analysis	**L**	**T**	**P**	**S**	**Semester:** 3rd
Course Code: MTHS202MJ	**4**	**x**	**X**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: To enable students to understand the fundamental concepts and properties of real numbers, and the behavior of sequences and series in the real number system.
Course Outcomes: After the completion of this course, the students shall be able to:
(i) Apply these concepts to determine convergence and divergence of real sequences and infinite series,
(ii) Explore new ideas in mathematical and modern analysis.

Unit-I: Real number system, Algebraic, Order and field structures, Bounded and unbounded sets of real numbers, supremum and infimum (lub and glb), order completeness property of **R**, Dedikind's property, Archimedean property, Neighbourhoods, limit points, interior and closure of a set, open and closed sets, Bolzano-weistrass theorem, cardinality of a set, countable and uncountable sets.

Unit-II: Sequences of real numbers, bounded sequences, convergence of sequences, limit and limit points of sequences, subsequences, Bolzano-weistrass theorem, limit inferior and limit superior, theorems on limit and convergence of sequences, Cauchy's crieteria for convergence, Cauchy sequences, bounded monotone sequences, Nested interval theorem.

Unit-III: Infinite series: convergence and divergence of a series, Necessary condition for convergence of a series, Geometric series, Series of positive terms: comparison tests, limit comparison test, D'Alembert's ratio test, Cauchy's root test, Raabe's test, Series of alternating terms: Leibniz's test, absolute and conditional convergence.

Unit-IV: Riemann integration: Partition of an interval, Refinement of a partition, upper and lower Darboux sums, definition of Riemann integral, necessary and sufficient condition for Riemann integrability(R-integrability), classes of R-integrability functions, primitives, Fundamental theorem of calculus, brief idea of improper integrals.

Text Books/ References

1. S. C. Malik and S. Arora, Mathematical Analysis, New Age International (P) Ltd, Publishers, 2005.
2. T. M. Apostol, Mathematical Analysis, Narosa Publications, 2002.
3. R. Goldberg, Methods of Real Analysis, Oxford IBM Publication, 1970.
4. W. Rudin, Principles of Mathematical Analysis, McGraw Hill, Indian Edition, 2017.
5. R. G. Bartle and D. R. Sherbert, Intoduction to real Analysis, Wiley, 2011.

Course Title: Applied Linear Algebra	**L**	**T**	**P**	**S**	**Semester:** 3rd
Course Code: MTHS203MJ	**3**	**x**	**2**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The course aims to introduce the fundamental concepts of linear algebra and develop problem solving skills through computational techniques using Python programming, enabling students to apply linear algebraic methods effectively in the fields of data science, artificial intelligence and machine learning.

Course Outcomes: After completing the course students will be able to

1. Perform matrix operations and applications using Python libraries for computational and visualization purposes.
2. Understand and apply the concepts of vector spaces, basis, dimension and rank of matrices in linear algebra.
3. Analyze and solve systems of linear equations using analytical and computational methods in Python and interpret and visualize their solutions.
4. Understand and compute linear transformations, eigenvalues and eigenvectors and understand the role of linear algebra in machine learning and AI models.

Prerequisites: An integrated computational lab for hands-on practice and students should also have basic Python programming skills.

Unit 1: Creating matrices using Python libraries: NumPy, SymPy and Pandas, performing matrix arithmetic operations: addition, subtraction, scalar multiplication and matrix multiplication using python libraries, Creation of special matrices using Numpy Library: Symmetric, Skew-Symmetric, Hermitian and Skew-Hermitian matrices, creation of upper triangular and lower triangular matrices, finding determinant of a matrix using linalg.det() function and inverse of a matrix using numpy.linalg.inv() function, demonstrating applications of matrices through Python-based computations and visualizations.

Unit II: Introduction to vector spaces, examples of vector spaces, linear combination, spanning sets, subspaces with examples, linearly dependent and independent sets of vectors**,** basis and dimension of a vector space**,** dimension and subspaces (basic relationship), application to matrices, rank of a matrix.

Unit III: Review of systems of linear equations: homogeneous and non-homogeneous systems, Matrix representation of systems: AX=B, augmented matrix, row echelon form. solution, Gaussian elimination method, Cramer's Rule (for small systems), existence and uniqueness of solutions: consistent vs. inconsistent systems, role of rank of a matrix in solvability (using numpy.linalg.matrix_rank), computational implementation using Python, Solving systems using numpy.linalg.solve, scipy.linalg and symbolic solving with sympy, Interpreting solutions: unique, infinite or no solution cases, visualizing 2D and 3D systems of equations using matplot.pyplotlib.

Unit IV: Definition of linear mappings (linear transformations) and examples**,** kernel and image of a linear mapping**,** rank and nullity of a linear mapping with examples. Eigen values and eigen vectors of a matrix**,** trace and determinant of a matrix expressed in terms of eigenvalues, computation of eigen values and eigenvectors of a matrix in Python, Matrix diagonalization and its computation using Sympy Library.

Textbooks/ References

1. Gilbert Strang, Linear Algebra and its Applications, Fourth Edition, Cengage India Private Limited by, 2005.
2. S. Lipschutz & M. Lipson, Linear Algebra, Schaum’s outline series, Tata McGraw-Hill, 4th Edition 2009.
3. M. Tsukada, Y. Kobayashi, H. Kaneko, Sin-E. Takahasi, K. Shirayanagi and M.Noguchi, Linear Algebra with Python-Theory and Applications, Springer 2023