Academic Council Meeting No. and Date: 09/ July 02, 2024

Agenda Number : 3 **Resolution Number : 41, 42 / 3.3, 3.23**

Vidya Prasarak Mandal's

B. N. Bandodkar College of Science (Autonomous), Thane

Syllabus for

Programme: Bachelor of Science

Specific Programme: Mathematics

[S.Y.B.Sc. MATHEMATICS]

Level 5.0

Choice Based Grading System

Revised under NEP

From Academic Year 2024-25

This page is intentionally left blank

Preamble

VPM'S B. N. Bandodkar College of Science Autonomous has changed the syllabus of S.Y.B.Sc. Mathematics from the academic year 2024-25 under NEP.

Mathematics is the most fundamental subject and an essential tool in the field of Science and Technology. The syllabus has been developed to prepare the students in pursuing research in Mathematics as well as to enhance their analytical skills and knowledge of mathematical tools and techniques required in industry for employment.

In recent decades, the extent of application of Mathematics to real world problems has increased by leaps and bounds. Taking into consideration the rapid changes in science and technology and new approaches in different areas of mathematics and related subjects like Physics, Statistics and Computer Sciences, the board of studies in Mathematics has prepared the syllabus of S.Y.B.Sc. Mathematics. The present syllabi of S. Y. B. Sc. for Semester III and Semester IV has been designed as per U.G.C. Model curriculum so that the students learn Mathematics needed for these branches, learn basic concepts of Mathematics and are exposed to rigorous methods gently and slowly. The syllabi would consist of two semesters and each semester would comprise of three courses for S.Y.B.Sc Mathematics. Course I is 'Calculus III and Multivariable Calculus I'. Calculus is applied and needed in every conceivable branch of science. Course II, 'Linear Algebra I and Linear Algebra II' develops mathematical reasoning and logical thinking and has applications in science and technology. Course III is "Ordinary differential equations" which is the applied computational technical skill.

PROGRAMME OUTCOMES (POs) OF BACHELOR OF SCIENCE (B.Sc.)

The Undergraduate Programmes of Science are intended to cater quality education and attain holistic development of learners through the following programme outcomes:

PO1 - Disciplinary Knowledge

Lay a strong foundation of conceptual learning in science. Instil ability to apply science in professional, social and personal life.

PO2 - Inculcation of Research Aptitude

Ignite spirit of inquiry, critical thinking, analytical skills and problem-solving approach which will help learners to grasp concepts related to research methodology and execute budding research ideas.

PO3 - Digital Literacy

Enhance ability to access, select and use a variety of relevant information e-resources for curricular, co-curricular and extracurricular learning processes.

PO4 - Sensitization towards Environment

Build a cohesive bond with nature by respecting natural resources, encouraging eco-friendly practices and creating awareness about sustainable development.

PO5 - Individuality and Teamwork

Encourage learners to work independently or in collaboration for achieving effective results through practical experiments, project work and research activities.

PO6 - Social and Ethical Awareness

Foster ethical principles which will help in developing rational thinking and becoming socially aware citizens. Build an attitude of unbiased, truthful actions and avoid unethical behaviour in all aspects of life.

Eligibility: F.Y.B.Sc.

Duration: 1 Year (SEM III and SEM IV)

Mode of Conduct: Offline

Total Credits for the Programme: 176

Starting year of implementation: 2024 - 25

Discipline/Subject: Mathematics

Programme Specific Outcomes

- To understand the basic concepts and fundamental theories of Mathematics
- To develop problem solving and computing skills
- To use mathematical concepts learnt for deducing proofs with logical reasoning
- To develop analytical skills and understanding of abstract theories of Mathematics
- To learn various mathematical tools and techniques and apply them in real world

Specific Programme: S.Y.B.Sc. (Mathematics - Major)

Assessment:

Weightage for assessments (in percentage) For Major and Minor

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	40%	60%

S. Y. B. Sc. Mathematics Structure of Programme

Semester III			
Major			
Course Code	**Course Title**	**No. of lectures in hours**	**Credits**
24BUMT3T01	Calculus III	**30**	**2**
24BUMT3T02	Linear Algebra I	**30**	**2**
24BUMT3T03	Ordinary Differential Equations I	**30**	**2**
24BUMT3P01	Practical based on 24BUMT3T01 and 24BUMT3T03	**60**	**2**
24BUMT3P02	Practical based on 24BUMT3T02 and 24BUMT3T03	**60**	**2**
24BUMT3P03	Field Project in Mathematics I	**60**	**2**
24BU3SEC03	Combinatorics II	**45**	**2**
	Total	**315**	**14**
Minor			
Course Code	**Course Title**	**No. of lectures in hours**	**Credits**
24BUMT3T04	Applications of Linear Algebra	**30**	**2**
	Total	**30**	**2**
Generic Elective			
Course Code	**Course Title**	**No. of lectures in hours**	**Credits**
24BUMT3T05	Graphs of functions	**30**	**2**
	Total	**30**	**2**

Semester IV			
Major			
Course Code	**Course Title**	**No. of lectures in hours**	**Credits**
24BUMT4T01	Multivariable Calculus I	**30**	**2**
24BUMT4T02	Linear Algebra II	**30**	**2**
24BUMT4T03	Ordinary Differential Equations II	**30**	**2**
24BUMT4P01	Practical based on 24BUMT4T01 and 24BUMT4T03	**60**	**2**
24BUMT4P02	Practical based on 24BUMT4T02 and 24BUMT4T03	**60**	**2**
24BUMT4P03	Field Project in Mathematics II	**60**	**2**
24BU4SEC03	Linear Algebra III	**45**	**2**
	Total	**315**	**14**
Minor			
Course Code	**Course Title**	**No. of lectures in hours**	**Credits**
24BUMT4T04	Applications of Calculus	**30**	**2**
	Total	**30**	**2**
Generic Elective			
Course Code	**Course Title**	**No. of lectures in hours**	**Credits**
24BUMT4T05	Numerical Methods	**30**	**2**
	Total	**30**	**2**

Semester III

Major Courses

24BUMT3T01

CO1	Interpret theoretical concept of Riemann Integration.	L2
CO2	Utilize the concept to solve the problems.	L3
CO3	Interpret the concepts of Improper Integral.	L2
CO4	Apply the concepts to Beta, Gamma functions	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	1	0
CO2	2	2	1	0	1	0
CO3	2	2	1	0	1	0
CO4	2	2	1	0	1	0

Course Code 24BUMT3T01	**Course Title Calculus III**	**Credits 2**	**No. of lectures 30**
Unit I :	**Riemann Integration** 1. Idea of approximating the area under a curve by inscribed circumscribed rectangles. Partitions of an interval. Refinement of a partition. Upper and lower sums for a bounded real valued function on a closed and bounded interval. Riemann integral. 2. Criterion for Riemann Integrability. Characterization of the Riemann integral as the limit of a sum. Examples. 3. Algebra of Riemann Integrable functions. 4. Riemann Integrability of continuous function and more generally of a bounded function whose set of discontinuities has only finitely many points. Riemann Integrability of monotone functions.		**15**
Unit II:	**Application of Integrations and Improper Integrals** 1. Area between the two curves. Lengths of plane curves. Surface area of surfaces of revolution. 2. First and Second Fundamental Theorems of Calculus.		**15**

	3. Mean Value Theorem. Integration by parts formula. Leibnitz's rule. 4. Definitions of two types of improper integrals. Necessary and sufficient condition for convergence. 5. Absolute convergence. Comparison and Limit form of Comparison test for convergence. 6. Gamma and Beta functions and their properties. Relationship between Gamma and Beta function.	

Books and References:					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Methods of Real Analysis	R. R. Goldberg	Oxford and IBH		1964
2.	Calculus and Analytic Geometry	Thomas and Finney	Addison-Wesley		1998
3.	Introduction to Real Analysis	R. G. Bartle and D. R. Sherbert	John Wiley & Sons		1994
4.	A course in Calculus and Real Analysis	Sudhir Ghorpade and Balmohan Limaye	Springer International Ltd.		2000
5.	Calculus Vol.2	T. Apostol	John Wiley		

24BUMT3T02

CO1	Summarize the concepts of System of Linear equations	L2
CO2	Solve the problems using Matrices	L3
CO3	Interpret the concepts of Vector space	L2
CO4	Justify the applications of vector space	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	1	0
CO2	2	2	1	0	1	0
CO3	2	2	1	0	1	0
CO4	2	2	1	0	1	0

Course Code 24BUMT3T02	Course Title Linear Algebra I	Credits 2	No. of lectures 30
Unit I :	**System of Linear Equations and Matrices** 1. Definition of a linear transformation of vector spaces; elementary properties, theorems,Examples. Sums and scalar multiples of linear transformations. Composites of linear transformations-examples.Gauss Elimination Method. 2. Null-space (kernel) and the image (range) of a linear transformation,consequences,examples. Nullity and Rank of a linear transformation. Rank-Nullity Theorem. 3. Matrix associated with linear transformation. Matrix of the composite of two linear transformations. Invertible linear transformations (isomorphism), Linear Operator.		**15**
Unit II :	**Vector Space over R** 1. Definition of a vector space over R. Subspaces; Examples of vector spaces, including the Euclidean space R^n, lines, planes and hyperplanes in R^n passing through the origin, space of systems of homogeneous linear equations, space of polynomials, space of various types of matrices. Intersections and sums of subspaces. Direct sum of vector spaces. Quotient space of a vector space by its subspace. 2. Linear combination of vectors. Linear span .Definition of finitely generated vector space. Linear dependence and independence of subsets of a vector space. 3. Basis of a vector space. Dimension of a vector space,theorems. Examples.		**15**

Books and References:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Elementary Linear Algebra	Howard Anton, Chris Rorres	Howard Wiley Student Edition	Twelfth	2018
2.	Introduction to Linear Algebra	Serge Lang	Springer International Ltd.	Second	2012
3.	Linear Algebra - A Geometric Approach	S Kumaresan	PHI Learning.	First	2000
4.	Linear Algebra Done Right	Sheldon Axler	Springer International Ltd.	Fourth	2023
5.	Linear Algebra with Applications	Gareth Williams	Jones and Bartlett Publishers	Ninth	2017

24BUMT3T03

CO1	Solve first order exact and non-exact ODEs and linear ODEs	L3
CO2	Explain the mathematical formulation of real-world problems using first order linear ODEs	L2
CO3	Prove results of second order homogeneous and non-homogeneous linear differential equations	L5
CO4	Solve second order homogeneous and non-homogeneous linear differential equations	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	0	1	0
CO2	2	1	1	0	1	0
CO3	2	1	1	0	1	0
CO4	2	1	1	0	1	0

Course Code 24BUMT3T03	**Course Title Ordinary Differential Equations I**	**Credits 2**	**No. of lectures 30**
Unit I :	**First Order First Degree Differential Equations** 1. Basics of ordinary differential equations 2. Exact equations of first order and first degree, non-exact equations and rules of finding integrating factors 3. Linear and reducible linear differential equations of first order, Bernoulli's differential equation 4. Applications of first order differential equations		**15**
Unit II :	**Second Order Linear Differential Equations** 1. Homogeneous and Non-homogeneous second order linear differential equations, Wronskian and linear independence of the solutions, General solution of homogeneous and non-homogeneous second order differential equation (with proofs) 2. Second order homogeneous linear differential equations with constant coefficients, the auxiliary equations, Roots of the auxiliary equations: real and distinct, real and repeated, complex conjugates. 3. Second order non-homogeneous linear differential equations with constant coefficients: The method of undetermined coefficients and The method of variation of parameters.		

Books and References:					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Ordinary Differential Equations A First Course	D Somasundaram	Narosa		2005
2.	Differential equations with applications and historical notes	George F. Simmons	McGraw Hill Education	Second	2017
3.	Elementary Differential Equations	Earl D. Rainville, Phillip E. Bedient and Richard E. Bedient	Publisher Pearson Education	Eight	2016
4.	Ordinary And Partial Differential Equations	M. D. Raisinghania	S. Chand		2005
5.	An Introduction to Ordinary Differential Equations	E. A. Coddington	Dover Books		1989
6.	Ordinary Differential Equations: Principles and Applications	A. K. Nandakumaran, P. S. Datti and Raju K. George	Cambridge University Press	First	2017

24BUMT3P01

CO1	Solve problems on Riemann Integration	L2
CO2	Solve problems on applications of Riemann Integration,	L2
CO3	Solve problems on Improper Integral.	L3
CO4	Solve first order exact and non-exact ODEs and linear ODEs	

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	3	0
CO2	2	2	1	0	3	0
CO3	2	2	1	0	3	0
CO4	2	0	0	0	3	0

Course Code 24BUMT3P01	Course Title Practical based on 24BUMT3T01 and 24BUMT3T03	Credits 2	No. of lectures 60
Practical 1	Calculation of Upper Sum, Lower Sum		4
Practical 2	Calculation integration using Riemann Sum		4
Practical 3	Properties of Riemann Integral		4
Practical 4	Problems on fundamental theorem of Calculus		4
Practical 5	Mean Value Theorems, Integration by parts, Leibnitz rule		4
Practical 6	Convergence of Improper Integrals.		4
Practical 7	Test for the convergence of improper integral		4
Practical 8	Beta Gamma functions		4
Practical 9	Area between the curve, Length of the curve		4
Practical 10	Miscellaneous Theoretical Questions based on paper I		4
Practical 11	Variable separable form and Linear substitution		4
Practical 12	Homogeneous and non-homogeneous first order linear ODE		4
Practical 13	Exact Differential Equations		4
Practical 14	Non-exact differential equations		4
Practical 15	Linear and reducible to linear equations		4
	Total		**60**

24BUMT3P02

CO1	Solve System of Linear equations and the problems using Matrices	L3
CO2	Solve the problems on concepts of Vector space and applications of vector space and linear dependence and independence.	L3
CO3	Solve the problems on Subspaces, Basis and Dimensions.	L3
CO4	Solve second order homogeneous and non-homogeneous linear differential equations with constant coefficients	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	3	0
CO2	2	2	1	0	3	0
CO3	2	2	1	0	3	0
CO4	2	0	0	0	3	0

Course Code 24BUMT3P02	**Course Title Practical based on 24BUMT3T02 and 24BUMT3T03**	**Credits 2**	**No. of lectures 60**
Practical 1	Systems of homogeneous linear equations.		4
Practical 2	Systems of non-homogeneous linear equations		4
Practical 3	Elementary row operations		4
Practical 4	Elementary column operations		4
Practical 5	Elementary matrices.		4
Practical 6	Vector spaces		4
Practical 7	Subspaces.		4
Practical 8	Linear Dependence, Linear Independence		4
Practical 9	Problems based on Basis and Dimension		4
Practical 10	Miscellaneous Theoretical Questions based on paper II		4
Practical 11	Applications of first order linear differential equations		4
Practical 12	General solution of second order homogeneous equations and Wronskian		4
Practical 13	Solving second order homogeneous equations with constant coefficients		4
Practical 14	Solving second order non-homogeneous ODEs using method of undetermined coefficients		4
Practical 15	Second order non-homogeneous ODEs using method of variation of parameters		4
	Total		**60**

Field Project in Mathematics I

24BUMT3P03

CO1	Formulate an appropriate research problem for field project	L6
CO2	Apply theoretical mathematical concepts to real-world situations or other disciplines, such as physics, engineering, economics, or computer science	L3
CO3	Conclude the results of the project	L5
CO4	Demonstrate the results through a report and presentation.	L2

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	0	1	1
CO2	2	2	2	0	1	1
CO3	2	2	2	0	1	1
CO4	2	2	2	0	1	1

Skill Enhancement Course

24BU3SEC03

CO1	Explain basic concepts of permutations, symmetric group, disjoint cycles, and transpositions.	L2
CO2	Solve problems based on basic concepts of permutations, symmetric group, disjoint cycles, and transpositions.	L3
CO3	Construct recurrence relations in counting problems such as Tower of Hanoi and Fibonacci sequence.	L3
CO4	Solve homogeneous and non-homogeneous recurrence relations using iterative and algebraic techniques.	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	0	1	0	1	0
CO2	2	0	1	0	1	0
CO3	2	0	1	0	1	0
CO4	2	0	1	0	1	0

Course Code 24BU3SEC03	Course Title Combinatorics II	Credits 2	No. of lectures 45
Unit I:	**Permutations and Recurrence relation** Permutation of objects, S_n, composition of permutations, results such as every permutation is a product of disjoint cycles, every cycle is a product of transpositions, signature of a permutation, even and odd permutations, cardinality of S_n, A_n. Recurrence Relations, definition of homogeneous, non-homogeneous, linear, non-linear recurrence relation, obtaining recurrence relations of Tower of Hanoi, Fibonacci sequence, etc. in counting problems, solving homogeneous as well as non-homogeneous recurrence relations by using iterative methods, solving a homogeneous recurrence relation of second degree using algebraic method proving the necessary result.		**15**
Practical 1	Permutations and S_n		**3**
Practical 2	Permutations and Cycles		**3**
Practical 3	Inverse of Permutation		**3**
Practical 4	Product of disjoint cycles		**3**
Practical 5	Signature of permutation		**3**
Practical 6	Linear Recurrence Relations		**3**
Practical 7	Linear Homogeneous Recurrence Relations		**3**
Practical 8	Solving Recurrence Relations using Iteration Method		**3**
Practical 9	Solving Recurrence Relations using Algebraic Method		**3**
Practical 10	Solving Linear Non-homogeneous Recurrence Relations		**3**
	Total		**45**

Books and References:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Discrete Mathematics	Norman Biggs	Oxford University Press		
2.	Introductory Combinatorics	Richard Brualdi	John Wiley and sons		
3.	Combinatorics-Theory	V. Krishnamurthy	Affiliated East		

	and Applications		West Press.		
4.	Discrete Mathematics and its Applications	-	Tata McGraw Hills		
5.	Discrete mathematics	-	Schaum's outline series		

Minor Courses

24BUMT3T04

CO1	Summarize the concept of system of linear equations and matrices	L2
CO2	Solve the problems based on system of linear equation	L3
CO3	Interpret the concepts of Eigenvalues, Eigenvectors	L2
CO4	Apply the concepts of Eigenvalues, Eigenvectors. for diagonalization	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	1	1
CO2	2	2	1	0	1	1
CO3	2	2	1	0	1	1
CO4	2	2	1	0	1	1

Course Code 24BUMT3T04	**Course Title Applications of Linear Algebra**	**Credits 2**	**No. of lectures 30**
Unit I :	**System of linear Equations and Matrices** 1. Systems of homogeneous and non-homogeneous linear equations,examples of finding solutions of such systems. Geometric and algebraic understanding of the solutions. Matrices (with real entries), Matrix representation of system of homogeneous and non-homogeneous linear equations. 2. Elementary row and column operations. Row equivalent matrices. Row reduction (of a matrix to its row echelon form). Gaussian elimination. Applications to solving systems of linear equations. Examples. 3. Elementary matrices. Invertibility of elementary matrices. Consequences, inverse of a matrix using Gauss elimination method.		**15**
Unit II:	**Eigenvalues, Eigenvectors and Diagonalization** 1. Eigenvalues and eigenvectors of a linear transformation, Eigen spaces. Algebraic and geometric multiplicity of an eigenvalue,examples. 2. Characteristic polynomial. Properties of characteristic polynomials (only statements). Examples. Cayley-Hamilton Theorem. Applications.		**15**

	3. Diagonalizable matrix, definition, properties, examples. Procedure for diagonalization of a matrix.	

Books and References:					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Elementary Linear Algebra	Howard Anton, Chris Rorres	Howard Wiley Student Edition	Twelfth	2018
2.	Introduction to Linear Algebra	Serge Lang	Springer International Ltd.	Second	2012
3.	Linear Algebra - A Geometric Approach	S Kumaresan	PHI Learning.	First	2000
4.	Linear Algebra Done Right	Sheldon Axler	Springer International Ltd.	Fourth	2023
5.	Linear Algebra with Applications	Gareth Williams	Jones and Bartlett Publishers	Second	2000

Generic Elective Course

24BUMT3T05

CO1	Outline graph of standard functions	L2
CO2	Construct graphs using shifting of graphs, stretching of graphs and reflecting graphs	L3
CO3	Find the type of functions - increasing, decreasing, concave upwards, concave downwards	L1
CO4	Identify critical points and points of Maxima and Minima of a function	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	0	1	0	0	0
CO2	2	0	1	0	0	0
CO3	2	0	1	0	0	0
CO4	2	0	1	0	0	0

Course Code 24BUMT3T05	**Course Title Graphs of Functions**	**Credits 2**	**No. of lectures 30**
Unit I:	Definition of Graph of a function. Sketching of graphs of functions such as Constant functions, step functions, linear functions, quadratic functions, absolute value functions, trigonometric functions, exponential functions, inverse functions, logarithmic functions. Sketching of graphs using shifting of graphs, stretching of graphs and reflecting graphs.		**15**
Unit II:	Increasing, decreasing functions, Maxima and Minima of a function, Concave up, concave down graphs. Point of inflection. Sketching of graphs of polynomial functions.		**15**

Books and References:					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Methods of Real Analysis	R. R. Goldberg	Oxford and IBH		1964
2.	Calculus and Analytic Geometry	Thomas and Finney	Addison-Wesley		1998

3.	Introduction to Real Analysis	R. G. Bartle and D. R. Sherbert	John Wiley & Sons		1994
4.	A Course in Calculus and Real Analysis	Sudhir Ghorpade and Balmohan Limaye	Springer International Ltd.		2000
5.	Calculus Vol.2	T. Apostol	John Wiley		

Semester IV

24BUMT4T01

CO1	Interpret the concepts of functions of several variables.	L2
CO2	Solve Limits, Continuity and Derivative of scalar and vector field functions.	L3
CO3	Interpret the concept of Derivative of scalar field and vector field functions.	L2
CO4	Solve Derivatives of Scalar and Vector field functions.	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	1	0
CO2	2	2	1	0	1	0
CO3	2	2	1	0	1	0
CO4	2	2	1	0	1	0

Course Code **24BUMT4T01**	**Course Title** **Multivariable Calculus I**	**Credits** **2**	**No. of lectures** **30**
Unit I :	**Functions of Several Variables** 1. Review of vectors in R^n and basic notations such as addition and scalar multiplication, inner product, length (norm), and distance between two points. 2. Real valued functions of several variables (Scalar fields), Vector valued functions of several variables (Vector fields). Component functions. Examples. 3. Sequences, Limits and Continuity: Sequences in R^n and their limits, Neighborhood's in R^n. Limits and continuity of scalar fields. Composition of continuous functions. Sequential characterizations. Algebra of limits and continuity. Iterated limits. Limits and continuity of vector fields. Algebra of Limits and continuity of vector fields. 4. Partial and directional derivatives of scalar fields. Definitions of directional derivatives and partial derivatives of scalar fields. Mean Value Theorem of scalar fields		**15**
Unit II:	**Differentiation of Scalar Fields** 1. Differentiability of Scalar Fields (in terms of linear transformation). The concept of total derivative. Uniqueness		**15**

	of total derivative of a differentiable function at a point. Examples of a function of two or three variables. Increment theorem. Basic properties including (i) continuity at a point of differentiability, (ii) existence of partial derivatives at a point of differentiability and (iii) differentiability when the partial derivatives exist and are continuous. 2. Gradient. Relation between total derivative and gradient of a function. Chain Rule. Geometric properties of Gradient. Tangent planes. 3. Euler's Theorem.Higher order partial derivatives. Mixed partial theorem (n = 2).	

Books and references:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1	Calculus Vol.2	T. Apostol	John Wiley		
2	A course in Multivariable calculus and Analysis	Ghorpade, Limaye	Springer		
3	Principals of Mathematical Analysis	Walter Rudin	McGraw- Hill		
4	Calculus	K. Stewart	Brooke/Cole publishing		

24BUMT4T02

CO1	Summarize the concept of Linear Transformations	L2
CO2	Solve the problems based on Linear Transformations.	L3
CO3	Interpret the concepts of Inner Products	L2
CO4	Apply the concepts of Orthogonal sets and Orthogonal Basis.	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	1	0
CO2	2	2	1	0	1	0
CO3	2	2	1	0	1	0
CO4	2	2	1	0	1	0

Course Code 24BUMT4T02	Course Title Linear Algebra II	Credits 2	No. of lectures 30
Unit I :	**Linear Transformations** 1. Definition of a linear transformation of vector spaces; elementary properties. Examples. Sums and scalar multiples of linear transformations. Composites of linear transformations. 2. Null-space (kernel) and the image (range) of a linear transformation. Nullity and Rank of a linear transformation. Rank-Nullity Theorem. 3. Matrix associated with linear transformation. Matrix of the composite of two linear transformations. Invertible linear transformations (isomorphism), Linear Operator.		**15**
Unit II :	**Inner Products and Orthogonality** 1. Inner product spaces (over R). Examples, Norm associated to an inner product. Cauchy-Schwarz inequality. Triangle inequality. 2. Angle between two vectors. Orthogonality of vectors. Pythagoras theorem and some geometric applications in R^2. Orthogonal sets, Orthonormal sets. Gram-Schmidt Orthogonalization process. Orthogonal basis and orthonormal basis for a finite-dimensional inner product space. 3. Orthogonal complement of any set of vectors in an inner product space. Orthogonal decomposition of an inner product space with respect to its subspace. Orthogonal projection of a vector onto a line (one dimensional subspace).		**15**

Books and References:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Elementary Linear Algebra	Howard Anton, Chris Rorres	Howard Wiley Student Edition	Twelfth	2018
2.	Introduction to Linear Algebra	Serge Lang	Springer International Ltd.	Second	2012
3.	Linear Algebra - A Geometric Approach	S Kumaresan	PHI Learning.	First	2000
4.	Linear Algebra Done Right	Sheldon Axler	Springer International Ltd.	Fourth	2023

24BUMT4T03

CO1	Solve higher order homogeneous linear differential equations with constant coefficients	L3
CO2	Apply inverse differential operators of standard functions	L3
CO3	Solve homogeneous linear system of ordinary differential equations with constant coefficients	L3
CO4	Construct explicit solutions of non-homogeneous linear systems with constant coefficients	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	0	1	0	1	0
CO2	2	0	1	0	1	0
CO3	2	0	1	0	1	0
CO4	2	0	1	0	1	0

Course Code 24BUMT4T03	**Course Title Ordinary Differential Equations II**	**Credits 2**	**No. of lectures 30**
Unit I :	**Higher order Linear Differential Equations** 1. Higher order homogeneous linear differential equations with constant coefficients, the auxiliary equations, Roots of the auxiliary equations: real and distinct, real and repeated, complex and complex repeated. 2. Higher order homogeneous linear differential equations with constant coefficients, the auxiliary equations, Roots of the auxiliary equations: real and distinct, real and repeated, complex and complex repeated. 3. An existence and uniqueness theorem, Wronskian and linear independence, General solution of homogeneous and non-homogeneous LDE (without proof) 4. The Differential operator and its properties, The inverse differential operator and particular integral, Evaluation of $\frac{1}{f(D)}$.		**15**

Unit II :	**Linear System of Ordinary Differential Equations** 1. Study of homogeneous linear system of ODEs in two variables, Existence and uniqueness theorems (only statement) 2. The Wronskian W(t) of two solutions of a homogeneous linear system of ODEs in two variables, result: W(t) is identically zero or nowhere zero on [a, b]. Two linearly independent solutions and the general solution of a homogeneous linear system of ODEs in two variables. 3. Explicit solutions of Homogeneous linear systems with constant coefficients in two variables, examples. 4. Explicit solutions of non-homogeneous linear systems with constant coefficients in two variables, examples.	**15**

Books and References:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1.	Ordinary Differential Equations A First Course	D Somasundaram	Narosa		2005
2.	Differential equations with applications and historical notes	George F. Simmons	McGraw Hill Education	Second	2017
3.	Elementary Differential Equations	Earl D. Rainville, Phillip E. Bedient and Richard E. Bedient	Publisher Pearson Education	Eight	2016
4.	Ordinary And Partial Differential Equations	M. D. Raisinghania	S. Chand		2005
5.	An Introduction to Ordinary Differential Equations	E. A. Coddington	Dover Books		1989
6.	Ordinary Differential Equations: Principles and Applications	A. K. Nandakumaran, P. S. Datti and Raju K. George	Cambridge University Press	First	2017

24BUMT4P01

CO1	Solve problems on Limits and continuity of Scalar and vector field functions.	L2
CO2	Solve problems on Derivatives of Scalar field and vector field functions.	L2
CO3	Solve problems on Higher Order Derivative	L3
CO4	Solve higher order homogeneous and non- homogeneous linear differential equations with constant coefficients	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	3	0
CO2	2	2	1	0	3	0
CO3	2	2	1	0	3	0
CO4	2	0	0	0	3	0

Course Code 24BUMT4P01	**Course Title Practical based on 24BUMT4T01 and 24BUMT4T03**	**Credits 2**	**No. of lectures 60**
Practical 1	Limits of Scalar fields and vector fields. Iterated limits.		4
Practical 2	Limits of Vector fields.		4
Practical 3	Iterated Limits, Limit along path		4
Practical 4	Continuous scalar field functions.		4
Practical 5	Computing directional derivatives, Partial derivatives.		4
Practical 6	Mean Value Theorem of scalar fields.		4
Practical 7	Differentiability of scalar fields. Total derivative. Gradient.		4
Practical 8	Chain Rule		4
Practical 9	Higher order derivative and mixed partial derivative of scalar fields.		4
Practical 10	Miscellaneous Theoretical Questions based on paper I		4
Practical 11	Wronskian in higher order linear differential equations		4
Practical 12	General solution of homogeneous higher order linear ODE with constant coefficients		4
Practical 13	Particular solution of homogeneous higher order linear ODE with constant coefficients		4

Practical 14	UDC method	4
Practical 15	Inverse Differential Operators - I	4
	Total	**60**

24BUMT4P02

CO1	Solve problems on concept of Linear Transformations and Inner Products	L2
CO2	Solve problems on the concepts of Rank-Nullity theorem and Linear Isomorphism.	L3
CO3	Solve problems on the concepts of Orthogonal sets and Orthogonal Basis.	L3
CO4	Construct explicit solutions of homogeneous and non-homogeneous linear systems with constant coefficients	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	3	0
CO2	2	2	1	0	3	0
CO3	2	2	1	0	3	0
CO4	2	0	0	0	3	0

Course Code 24BUMT4P02	**Course Title Practical based on 24BUMT4T02 and 24BUMT4T03**	**Credits 2**	**No. of lectures 60**
Practical 1	Linear transformation		4
Practical 2	Kernel and Image of Linear transformation		4
Practical 3	Problems on Rank-Nullity Theorem		4
Practical 4	Linear Isomorphism of Linear transformation		4
Practical 5	Matrix associated with Linear transformations		4
Practical 6	Inner product and properties		4
Practical 7	Projection, Orthogonal complements.		4
Practical 8	Problems on Orthogonal sets, orthonormal sets		4

Practical 9	Gram-Schmidt Orthogonalization	4
Practical 10	Miscellaneous Theoretical Questions based on Paper II	4
Practical 11	Inverse Differential Operators - II	4
Practical 12	Inverse Differential Operators - III	4
Practical 13	Wronskian in a linear system of ODE	4
Practical 14	Explicit solutions of Homogeneous linear systems with constant coefficients in two variables	4
Practical 15	Explicit solutions of non-homogeneous linear systems with constant coefficients in two variables	4
	Total	**60**

Field Project in Mathematics II

24BUMT4P03

CO1	Formulate an appropriate research problem for field project	L6
CO2	Apply theoretical mathematical concepts to real-world situations or other disciplines, such as physics, engineering, economics, or computer science	L3
CO3	Conclude the results of the project	L5
CO4	Demonstrate the results through a report and presentation.	L2

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	0	1	1
CO2	2	2	2	0	1	1
CO3	2	2	2	0	1	1
CO4	2	2	2	0	1	1

Skill Enhancement Course

24BU4SEC03

CO1	Solve matrices to find Eigen Values and Eigen vectors.	L3
CO2	Apply the Cayley-Hamilton theorem and properties of characteristic polynomials	L3
CO3	Apply the procedure of Diagonalization of Matrix.	L3
CO4	Apply to quadratic forms and classification of conic sections.	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	0	1	0	1	0
CO2	2	0	1	0	1	0
CO3	2	0	1	0	1	0
CO4	2	0	1	0	1	0

Course Code 24BU4SEC03	**Course Title Linear Algebra III**	**Credits 2**	**No. of lectures 45**
Unit I:	**Eigenvalues, Eigenvectors and Diagonalization** 1. Eigenvalues and eigenvectors of a linear transformation of a vector space into itself and of square matrices. The eigenvectors corresponding to distinct eigenvalues of a linear transformation are linearly independent. Eigen spaces. Algebraic and geometric multiplicity of an eigenvalue. 2. Characteristic polynomial. Properties of characteristic polynomials (only statements). Examples. Cayley-Hamilton Theorem. Applications. 3. Invariance of the characteristic polynomial and eigenvalues of similar matrices. 4. Diagonalizable matrix. A real square matrix A is diagonalizable if and only if there is a basis of R^n consisting of eigenvectors of A. (Statement only – A_{nxn} is diagonalizable if and only if sum of algebraic multiplicities is equal to sum of geometric multiplicities of all the eigenvalues of A = n). Procedure for diagonalization of a matrix.		**15**

	5. Spectral Theorem for Real Symmetric Matrices (Statement only). Examples of orthogonal diagonalization of real symmetric matrices. Applications to quadratic forms and classification of conic sections.	
Practical 1	Eigenvalues of 2×2 matrix	**3**
Practical 2	Eigenvalues of 3×3 matrix	**3**
Practical 3	Eigenvectors	**3**
Practical 4	Eigenspaces	**3**
Practical 5	Cayley Hamilton Theorem	**3**
Practical 6	Geometric and Algebraic Multiplicity of Eigenvalue	**3**
Practical 7	Diagonalization of matrix I	**3**
Practical 8	Diagonalization of matrix II	**3**
Practical 9	Orthogonal diagonalization of symmetric matrix	**3**
Practical 10	Application to Conics	**3**
	Total	**45**

Books and References:

Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	Elementary Linear Algebra	Howard Anton, Chris Rorres	Wiley Student Edition		
2.	Introduction to Linear Algebra	Serge Lang	Springer International Ltd.		
3.	Linear Algebra - A Geometric Approach	S Kumaresan	PHI Learning.		
4.	Linear Algebra done right	Sheldon Axler	Springer International Ltd.		
5.	Linear Algebra with Applications	Gareth Williams	Jones and Bartlett Publishers		

Minor Course

24BUMT4T04

CO1	interpret the concepts of Integrations and Differentiation.	L2
CO2	solve Improper Integrals and Application of Integrations	L3
CO3	interpret the concepts of Derivatives of Scalar and Vector fields function.	L2
CO4	interpret the concepts of Integrations. and Differentiation. apply Differentiation of Scalar Fields and Vector Fields.	L3

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	0	1	1
CO2	2	2	1	0	1	1
CO3	2	2	1	0	1	1
CO4	2	2	1	0	1	1

Course Code 24BUMT4T04	**Course Title Applications of Calculus**	**Credits 2**	**No. of lectures 30**
Unit I :	**Application of Integrations and Improper Integrals** 1. Area between the two curves. Lengths of plane curves. Surface area of surfaces of revolution. First and Second Fundamental Theorems of Calculus.(statements only) Mean Value Theorem. Integration by parts formula. Leibnitz's rule. 2. Definitions of two types of improper integrals. Necessary and sufficient condition for convergence. Absolute convergence. Comparison and Limit form of Comparison test for convergence. Gamma and Beta functions and their properties. Relationship between Gamma and Beta function.		**15**
Unit II:	**Applications of Differentiation of Scalar Fields and Vector Fields** 1. Application of Differentiation of Scalar Fields. The maximum and minimum rate of change of Scalar Field. Taylor's Theorem for twice continuously differentiable function. Notion of local maxima, local minima and saddle points. First Derivative Test. Examples.		**15**

	2. Differentiation of Vector Fields. Differentiability and the notion of total derivative. Differentiability of a vector field implies continuity. Jacobian Matrix. Relationship between the total derivative and Jacobian matrix. The chain rule for derivative of a vector fields (statements only).	

Books and References:

Sr. No.	Title	Author/s	Publisher	Edition	Year
1	Methods of Real Analysis	R. R. Goldberg	Oxford and IBH	Second	1964
2	Calculus Vol.2	T. Apostol	John Wiley	Second	
3	A course in Multivariable calculus and Analysis	Ghorpade, Limaye	Springer	Second	2009
4	Principles of Mathematical Analysis	Walter Rudin	McGraw- Hill	Third	2023

Generic Elective Course

24BUMT4T05

CO1	Solve iteration methods for finding approximate solution of algebraic and transcendental equations	L3
CO2	Apply direct methods and iterative methods for solving system of linear equations	L3
CO3	Apply methods for finding polynomial approximation using interpolation, linear and quadratic curve fitting	L3
CO4	Find derivative and integration using numerical methods	L1

Grading will be as 3: High(>60%), 2: Moderate(40%-60%), 1: Low(<40%), 0: No mapping

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	0	0	0
CO2	2	1	1	0	0	0
CO3	2	1	1	0	0	0
CO4	2	1	1	0	0	0

Course Code 24BUMT4T05	**Course Title Numerical Methods**	**Credits 2**	**No. of lectures 30**
Unit I:	**Solution of Algebraic Equations, Transcendental Equations and System of Linear Equations** 1. Iteration methods for simple roots: Method of bisection, Newton-Raphson method, Secant method, Regula-Falsi method and Fixed point iteration method 2. Direct methods for solving system of linear equations: Gauss Elimination method and Cramer's rule 3. Iterative methods for solving system of linear equations: Gauss-Jacobi Iteration method, Gauss-Seidel Iteration method		**15**
Unit II:	**Interpolation and Curve fitting, Numerical Differentiation and Integration** 1. Interpolation: Lagrange's Interpolation, Newton's forward difference interpolation and Newton's backward difference interpolation 2. Curve fitting: Linear and Quadratic 3. Numerical Differentiation based on Newton's forward difference interpolation and Newton's backward difference interpolation 4. Numerical Integration: Trapezoidal Rule, Simpson's 1/3rd Rule, Simpson's 3/8th Rule		**15**

Books and References:					
Sr. No.	**Title**	**Author/s**	**Publisher**	**Edition**	**Year**
1.	An Introduction to Numerical Analysis	Kendall E. and Atkinson	Wiley		
2.	Numerical Methods for Scientific and Engineering Computation	M. K. Jain, S. R. K. Iyengar and R. K. Jain	New Age International Publications		
3.	Introductory methods of Numerical Analysis	S. Sastry	PHI Learning		
4.	Numerical Methods: Fundamentals and Applications	Rajesh Kumar Gupta	Cambridge University Press		2019
5.	Numerical Methods	P. Kandasamy, K. Thilagavathy and K. Gunavati	S Chand		2006
6.	Numerical Methods	E. Bal Guruswamy	McGraw Hill Education		2017

Curriculum mapping for the Undergraduate Degree Programme S.Y.B.Sc. Mathematics

	SEMESTER – III	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Major Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
24BUMT3T01	Calculus III							
24BUMT3T02	Linear Algebra I							
24BUMT3T03	Ordinary Differential Equations I							
24BUMT3P01	Practical based on Paper I and III			✓				
24BUMT3P02	Practical based on Paper II and III			✓				
24BUMT3P03	Field Project in Mathematics I			✓				
24BU3SEC03	Combinatorics II							
	Minor Course Title							
24BUMT3T04	Applications of Linear Algebra							
Course Code	**Generic - Course Title**							
24BUMT3T05	Graphs of functions							
09	***Total***			**3**				

	SEMESTER – IV	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**Major Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
24BUMT4T01	Multivariable Calculus I							
24BUMT4T02	Linear Algebra II							
24BUMT4T03	Ordinary Differential Equations II							
24BUMT4P01	Practical based on Paper I and III			✓				
24BUMT4P02	Practical based on Paper II and III			✓				
24BUMT4P03	Field Project in Mathematics II			✓				
24BU4SEC03	Linear Algebra III							
	Minor Course Title							
24BUMT4T04	Applications of Calculus							
Course Code	**Generic - Course Title**							
24BUMT4T05	Numerical Methods							
09	***Total***			**3**				