Hindi Vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College

of Arts, Science & Commerce

(Autonomous College)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for the S.Y.B.Sc.

Program: B.Sc. Mathematics

Program Code: RJSUMAT

(CBCS 2021-2022)

THE PREAMBLE

Why Mathematics?

Mathematics is the language of all Science, Engineering, and technology. Mathematics is considered the queen of sciences. Without Mathematics, there can be neither science nor engineering. Mathematics occupies a crucial and unique role in human societies and represents a strategic key in the development of the whole of mankind. Mathematics is around us. It is present in different forms; the list is just endless if one goes on to note down the situations when our computational skill, or more specifically, simple mathematics comes to play a role, almost every next moment we do the simple calculations at the back of our mind. Of course, these are all done pretty unconsciously without a thought being spared for the use of mathematics on all such occasions. Mathematics helps the man to give exact interpretation to his ideas and conclusions. It is the numerical and calculation part of man's life and knowledge. It plays a predominant role in our everyday life and it has become an indispensable factor for the progress of our present-day world. Further, In modern times, the adoption of mathematical methods in the social, medical and physical sciences has expanded rapidly, confirming mathematics as an indispensable part of undergraduate curricula and creating a great demand for mathematical training. Much of the demand stems directly from the need for mathematical modelling of phenomena. Such modelling is basic to all engineering, plays a vital role in all physical sciences and contributes significantly to the biological sciences, medicine, psychology, economics and commerce. The numerous applications of the subject in almost every field makes mathematics the most versatile subject choice.

Why Mathematics at R J College?

The department of Mathematics of R J College is the department as old as the college itself. It started in 1963, the inception year of the college and since then has remained as the centre of academic activities for the subject. With a legacy of more than 6 decades, today the department offers undergraduate programs in the subject of mathematics with more than one discipline-specific elective paper and is affiliated to, and recognized by the University of Mumbai. As an applied component in the final year, mathematics students learn computer programming languages like Java, SQL, and python along with system analysis. Series of guest lectures, Problem-solving sessions, lecture-based learning, bridge courses, institute visits etc. motivate students to explore more in terms of applications of the subject. Under autonomy, the department has made the curriculum more robust by incorporating skill-based learning and value-added course that imparts practical knowledge of the subject to the students. Every year the department organizes a seminar competition on the theme 'Applications of Mathematics' in various areas. Department of Mathematics also runs a value-added course in a year and is able to attract students from other disciplines of science enrolling for these courses. Department of mathematics has received funding from the Department of Biotechnology (DBT), New Delhi to further strengthen our hands in being able to provide hands-on training to the students to satisfy their curiosity and inculcate research aptitude.

Our Curriculum, Your Strength

The syllabus for mathematics for the total six semesters is meticulously designed so as to make students understand the diversity of subject. From learning elementary calculus and basic algebra, students move on to applied aspects of the subject in terms of Real analysis, multivariable calculus, Complex analysis, abstract algebra. Specialized training in differential equations, numerical methods is a part of the learning process. The teaching staff of the department of mathematics are highly qualified and are dedicated to their subjects giving a friendly environment for the students. The department always aims to develop skills, ideas and overall progress of the students. Many of our students participate and get awards in various activities like MTTS program, Madhava Mathematics competition and other competitive exams. The environment of the department is very friendly which is useful for the students coming from other colleges also.

DISTRIBUTION OF TOPICS AND CREDITS

S.Y.B.Sc. MATHEMATICS SEMESTER III

Course	Nomenclature	Credits	Topics
RJSUMAT301	Calculus-III	02	1. Riemann integration 2. Infinite Series 3. Improper integrals
RJSUMAT302	Algebra-III	02	4. Vector spaces 5. Basis and Dimension of a finite dimensional real vector space 6. Linear transformations and matrices
RJSUMAT303	Numerical Methods	02	7. Root-Finding 8. Interpolation 9. Numerical Differentiation and Integration
RJSUMATP301	Practical I	03	Riemann integration, infinite series, improper integrals, vector spaces, basis and dimension of a finite dimensional real vector space, linear transformations and matrices

S.Y.B.Sc. MATHEMATICS SEMESTER IV

Course	Nomenclature	Credits	Topics
RJSUMAT401	Multivariable Differential Calculus	02	1. Functions of several variables 2. Differentiation 3. Applications of differentiation
RJSUMAT402	Algebra-IV	02	4. Inner product spaces 5. Quotient spaces, orthogonal linear transformations and characteristic polynomials 6. Eigenvalues, eigenvectors and diagonalisation
RJSUMAT403	Differential Equations	02	7. First Order ODEs 8. Second Order ODEs 9. System of First Order ODEs
RJSUMATP401	Practical II	03	Functions of several variables, differentiation, applications of differentiation, inner product spaces, quotient spaces, orthogonal linear transformations and characteristic polynomials, eigenvalues, eigenvectors and diagonalisation, first order ODEs, second order ODEs, system of first order ODEs

SEMESTER III (THEORY)			**L**	**Cr**
Paper-I: Calculus- III		**Paper Code:** RJSUMAT301	45	2
UNIT I			15	
RIEMANN INTEGRATION				
1	Approximation of area, upper and lower Riemann sums and their properties, upper and lower integrals, concept of Riemann integration, Riemann criterion for integrability, basic results on Riemann integration, examples of non-Riemann integrable functions, Fundamental theorems of calculus, integration by substitution, integration by parts, mean value theorems for integrals, Leibnitz rule.			
UNIT II			15	
INFINITE SERIES				
1	Infinite series of real numbers, convergence of series, Necessary condition for convergence of series, Algebra of convergent series, Cauchy's criterion, binomial series, harmonic series, p-harmonic series, Convergence tests and examples, alternating series, Leibnitz test for alternating series, absolute convergence, conditional convergence, Cauchy product, Grouping and rearrangement of terms of series.			
UNIT III			15	
IMPROPER INTEGRALS				
1	Improper integrals of 1^{st} kind and 2^{nd} kind, convergence of improper integrals, Cauchy criterion, comparison tests, Abel's test and Dirichlet's test.			
2	Beta and gamma functions and their properties, relationship between beta and gamma functions, duplication formula.			

S.Y.BSc	Semester I Theory : Calculus-III
RJSUMAT301 Paper I Calculus- III	Course Outcomes3.1 : 1. Approximating area using Riemann upper and lower sums and finding Riemann integral of functions using definition. 2. To characterize class of Riemann integrable functions and some basic results. 3. To Study Fundamental theorems of calculus, mean value theorems for integrals and integration by parts. 4. Learning series of real numbers and its behavior using sequence of partial sums and some tests for convergence. 5. To analyze behavior of two improper integrals using some tests. 6. To introduce beta and gamma functions. Learning outcomes: ➢ To know actual definition of integration. ➢ Relations between derivative and integral. ➢ Series of real numbers and its convergence. ➢ Grouping and rearrangements of terms of series. ➢ Study of improper integrals and their applications. ➢ To study beta and gamma functions and their relations.

SEMESTER III (THEORY)			**L**	**Cr**
Paper-II: Algebra-III		**Paper Code:** RJSUMAT302	45	2
UNIT I			15	
VECTOR SPACES				
1	Real vector space and its examples. Properties of a real vector space Subspace of a real vector space and its examples. Basic theorems on subspaces. Finite linear combinations of vectors in a vector space; the linear span $L(S)$ of a non-empty subset S of a vector space.Linearly independent/linearly dependent subsets of a vector space and theorems based on it.			
UNIT II			15	
BASIS AND DIMENSION OF A FINITE DIMENSIONAL REAL VECTOR SPACE				
1	Basis of a real vector space, dimension of a real vector space, maximal linearly independent subset of a vector space, minimal generating set of a vector space.Theorems on number of elements in the basis of a real vector space. Extending any basis of a subspace W of a vector space V to a basis of the vector space V.			
2	Row space, column space of an m x n matrix, row rank and column rank of a matrix. Review of determinants.			
UNIT III			15	
LINEAR TRANSFORMATIONS AND MATRICES				
1	Linear transformations, Kernel, Image of a linear transformation, Rank T, Nullity T.Properties of a linear transformation.Basic theorems on linear transformation. Rank nullity theorem and examples. Linear isomorphisms, inverse of a linear isomorphism.Representation of linear maps by matrices(associated matrix) and effect under a change of basis, examples. Equivalence of rank of an mxn matrix A and rank of the linear transformation $L_A: \mathbb{R}^n \to \mathbb{R}^m (L_A(X) = AX)$.			

<table>
<tr><td>S.Y.BSc</td><td>Semester III Theory : Algebra-III</td></tr>
<tr><td>RJSUMAT302

Paper II

Algebra-III</td><td>Course Outcomes3.2 :

1. Real Vector spaces/Subspaces and their properties.
2. Basis and dimensions of a real vector space.
3. Linear transformation, linear isomorphism and their properties.
Learning outcomes:

➢ Learning concepts like linear span, linearly dependent/ independent set.
➢ Learning concepts like basis is a maximal linearly independent set and also minimal generating set of a real vector space.
➢ Learn to find kernel, image, rank and nullity of a linear transformation.
➢ Learn to relate linear transformation with its associated matrix.</td></tr>
</table>

			L	Cr
SEMESTER III (THEORY)			**L**	**Cr**
Paper-III: Numerical Methods		**Paper Code:** RJSUMAT303	45	2
UNIT I			15	
ROOT-FINDING				
1	Measures of errors: relative, absolute and percentage errors. Types of errors: Inherent error, round-off error and truncation error. Significant digits. Review of Taylor's series, intermediate value theorem, mean value theorems.			
2	Bisection method, Newton-Raphson method, Secant method, Regula-Falsi method, Fixed point iteration. Conditions of convergence and the rate of convergence of all these methods.			
UNIT II			15	
INTERPOLATION				
1	Interpolating polynomials, Lagrange's interpolation. Linear, Quadratic and Higher order interpolations. Finite difference operators: Shift, forward difference, backward difference, central difference, average operators and relations between them. Difference tables. Interpolating polynomials using finite differences (for evenly spaced points): Newton's forward difference interpolation, Newton's backward difference interpolation. Stirling's interpolation.			
UNIT III			15	
NUMERICAL DIFFERENTIATION AND INTEGRATION				
1	Numerical differentiation based on interpolation. Numerical differentiation based on finite differences (forward, backward and central).			
2	Numerical Integration based on interpolation. Newton-Cotes Methods, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule. Determination of error terms for all these methods. Composite numerical integration.			

<table>
<tr><td>S.Y.BSc</td><td>Theory Semester III : Numerical Methods</td></tr>
<tr><td>RJSUMAT303
paper III
Numerical
Methods</td><td>Course Outcomes3.3 :
1. To understand Newton-Raphson method, Secant method, Regula-Falsi method, and their rate of convergence.
2. To learn Lagrange's and Newton's interpolation formulae.
3. To learn numerical differentiation through interpolation.
4. To learn numerical integration methods: trapezoidal rule, Simpson's rule.
Learning outcomes:
➢ To understand various types of errors and their sources
➢ To learn methods of finding approximate roots of equations.
➢ To be able to implement various numerical method techniques to compute derivatives and integrations.</td></tr>
</table>

			L	Cr
SEMESTER IV (THEORY)			**L**	**Cr**
Paper-I: Multivariable Differential Calculus		**Paper Code: RJSUMAT401**	45	2
UNIT I			15	
FUNCTIONS OF SEVERAL VARIABLES				
1	Euclidean space $\mathbb{R}^n$, Euclidean norm function on $\mathbb{R}^n$,open ball and open sets in $\mathbb{R}^n$, sequences in $\mathbb{R}^n$, convergence of sequences and basic properties, subsequences (These concepts should be specifically discussed for $\mathbb{R}^2$ and $\mathbb{R}^3$).			
2	Functions from $\mathbb{R}^n$ to $\mathbb{R}$ (scalar fields) and from $\mathbb{R}^n$ to $\mathbb{R}^m$ (vector fields), limits and continuity of scalar fields and vector fields, basic results on algebra of limits and continuity, nonexistence of limits, relation between continuity of vector field and its component functions.			
3	Directional Derivatives and partial derivatives of scalar fields, higher order partial derivatives, gradient of a scalar field, mean value theorem for derivatives of scalar fields.			
UNIT II			15	
DIFFERENTIATION				
1	Differentiability of a scalar field at a point of $\mathbb{R}^n$ (in terms of linear transformation) and on open subsets of $\mathbb{R}^n$, the total derivative and its properties, necessary condition for differentiability, sufficient condition for differentiability, chain rule for derivatives of scalar fields, homogeneous functions and Euler's theorem, sufficient condition for equality of mixed partial derivatives.			
2	Derivatives of vector fields, differentiability in terms of linear transformation, Jacobian matrix, differentiability of scalar field implies its continuity, chain rule for derivatives of vector fields.			
UNIT III			15	
APPLICATIONS OF DIFFERENTIATION				
1	Geometric properties of gradient of a scalar field, applications to geometry, level sets, tangent planes, Taylor's formula for functions of two variables, linear approximation, quadratic approximation, Hessian matrix, extreme values, saddle points, first derivative test, second partial derivative test, method of Lagrange's Multipliers.			

S.Y.BSc	Theory Semester IV : Multivariable Differential Calculus
RJSUMAT401 Paper I Multivariable Differential Calculus	Course Outcomes4.1 : 1. To extend the concept of limit and continuity for multivariable functions. 2. To study directional derivatives, partial derivatives and Mean value theorem for derivatives of scalar fields. 3. To define total derivative as a linear transformation and to discuss relations between directional derivatives, partial derivatives and total derivatives. 4. To discuss chain rule for scalar fields, higher order and mixed partial derivatives. 5. To understand differentiability of vector fields, special matrices viz. Jacobian and Hessian. 6. To study methods of finding maxima and minima for functions of two variables. Learning outcomes: ➢ Various definitions of derivatives of multivariable functions. ➢ Applications to find extreme values. ➢ Calculus for scalar and vector fields.

			L	Cr
SEMESTER IV (THEORY)			**L**	**Cr**
Paper-II: ALGEBRA-IV		**Paper Code: RJSUMAT402**	45	2
UNIT I			15	
INNER PRODUCT SPACES				
1	Dot product in $\mathbb{R}^n$. Definition of general inner product on a vector space over $\mathbb{R}$. Examples of inner product. Norm of a vector in an inner product space. Cauchy-Schwartz inequality, Triangle inequality, Orthogonality of vectors, Pythagoras theorem and geometric applications in $\mathbb{R}^2$, Projections on a line, the projection being the closest approximation, orthogonal complements of a subspace, Orthogonal complements in $\mathbb{R}^2$and$\mathbb{R}^3$. Orthogonal sets and orthonormal sets in an inner product space, Orthogonal and orthonormal bases. Gram-Schmidt orthogonalization process, Simple examples in $\mathbb{R}^3$and $\mathbb{R}^4$.			
UNIT II			15	
QUOTIENT SPACES, ORTHOGONAL LINEAR TRANSFORMATIONS AND CHARACTERISTIC POLYNOMIALS				
1	Cosets, Quotient Spaces, First Isomorphism theorem of real vector spaces Dimension and basis of the quotient space V/W , when V is finite dimensional.			
2	Orthogonal transformations, Translations and Reflections with respect to a hyperplane, Orthogonal transformation of $\mathbb{R}^2$.			
3	Characteristic polynomial of an $n \times n$ real matrix. Cayley Hamilton Theorem and its Applications.			
UNIT III			15	
EIGENVALUES, EIGEN VECTORS AND DIAGONALISATION				
1	Eigen values and eigen vectors of a linear transformationof a finite dimensional real vector space to itselfand examples, Eigen values and Eigen vectors of $n \times n$ real matrices. Theorems on eigen values and eigen vectors. The characteristic polynomial of a linear transformation of a finite dimensional real vector space to itself. Similarmatrices, Relation with change of basis, Invariance of the characteristicpolynomial and (hence of the) eigenvalues of similar matrices.Geometric multiplicity and Algebraic multiplicity of eigen values of an $n \times n$real matrix. Diagonalizable matrix. Diagonalisation of a linear transformation of a finite dimensional real vector space to itself.			

<table>
<tr><td>S.Y.BSc</td><td>Theory Semester IV : Algebra-IV</td></tr>
<tr><td>RJSUMAT402

Paper II

Algebra-IV</td><td>Course Outcomes4.2 :

1. Inner product spaces and their properties .
2. Cauchy-Schwartz inequality, Triangle inequality, Orthogonality of vectors, Pythagoras Theorem in an Inner product space.
3. Quotient spaces and Isomorphism theorems on real vector spaces.
4. Orthogonal transformations, Characteristic polynomials and Cayley Hamilton Theorem.
5. Eigen values and eigen vectors, similar matrices.
6. Diagonalisation of a square matrix with respect to eigen values / eigen vectors.
Learning outcomes:

➢ Learn to find product of two vectors in a real vector space.
➢ Learn to find angle and distance between two vectors in a real vector space.
➢ Learn to find corresponding orthogonal/orthonormal set from a linearly independent set in a real vector space.
➢ Learn to find eigen values and eigen vectors of a linear transformation or its associated matrices.
➢ Learn to find reflection map about a hyperplane.
➢ Learn to check whether two matrices are similar.
➢ Learn to find Geometric and Algebraic multiplicity of an eigen value.
➢ 8. Learn to check whether a square matrix or a linear transformation is diagonalizable.</td></tr>
</table>

<table>
<tr><td colspan="3">SEMESTER IV (THEORY)</td><td>L</td><td>Cr</td></tr>
<tr><td colspan="2">Paper-III: DIFFERENTIAL EQUATIONS</td><td>Paper Code: RJSUMAT403</td><td>45</td><td>2</td></tr>
<tr><td colspan="3">UNIT I</td><td>15</td><td></td></tr>
<tr><td colspan="3">FIRST ORDER ODEs</td><td></td><td></td></tr>
<tr><td>1</td><td colspan="2">Definitions of: Differential Equation, Order and Degree of a differential equation, Ordinary Differential Equation (ODE), Linear and nonlinear ODE.</td><td></td><td></td></tr>
<tr><td>2</td><td colspan="2">Picard's theorem (only statement), Lipschitz Condition, Existence-uniqueness theorem for vertical strips (only statement). Examples based on verifying the conditions of the existence and uniqueness theorem.</td><td></td><td></td></tr>
<tr><td>3</td><td colspan="2">Review of solution of homogeneous and non-homogeneous linear differential equations of first order and first degree. Exact Equations: General Solution of Exact equations of first order and first degree, Necessary and sufficient condition for $Mdx + Ndy = 0$ to be exact. Non-exact equations: Rules for finding integrating factors (without proof) for non-exact equations.</td><td></td><td></td></tr>
<tr><td>4</td><td colspan="2">Linear and reducible to linear equations, Bernoulli's differential equation. Applications to orthogonal trajectories, population growth, and finding the current at a given time.</td><td></td><td></td></tr>
<tr><td colspan="3">UNIT II</td><td>15</td><td></td></tr>
<tr><td colspan="3">SECOND ORDER ODEs</td><td></td><td></td></tr>
<tr><td>1</td><td colspan="2">Existence and Uniqueness Theorem for second order (without proof): statement and examples.</td><td></td><td></td></tr>
<tr><td>2</td><td colspan="2">Homogeneous and nonhomogeneous second order linear differentiable equations: The space of solutions of the homogeneous equation as a vector space. Wronskian and linear independence of the solutions. The general solution of homogeneous differential equations. The general solution of a nonhomogeneous second order equation. Complementary functions and particular integrals.</td><td></td><td></td></tr>
<tr><td>3</td><td colspan="2">The homogeneous equation with constant coefficients, auxiliary equation. The general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation. The Cauchy-Euler equation, Reduction of order.</td><td></td><td></td></tr>
<tr><td>4</td><td colspan="2">Nonhomogeneous second order differential equations: The method of undetermined coefficients. The method of variation of parameters.</td><td></td><td></td></tr>
</table>

	UNIT III	15	
	SYSTEM OF FIRST ORDER ODEs		
1	Terminologies: linear, nonlinear, homogeneous and nonhomogeneous systems. Conversion of second order ODEs to a system of first order ODEs and vice-versa. Solution of a linear system by elimination.		
2	Existence and uniqueness theorem for the system of differential equations (only statement), Wronskian and general solution of homogeneous linear systems.		
3	Matrix method for solving the homogeneous system of ODEs with constant coefficients. Phase plane, trajectory and phase portrait of a linear system.		
4	Nonhomogeneous linear system of ODEs with constant coefficients.		

S.Y.BSc	Theory Semester IV : Differential Equations
RJSUMAT403 Paper III Differential Equations	Course Outcomes4.3 : 1. To study classification of differential equations, linear and nonlinear differential equations, homogeneous, nonhomogeneous, exact, Bernoulli's differential equations. 2. To learn some applications of first order differential equations. 3. To learn methods of solving second order differential equations with constant coefficients. 4. To study methods of solving non homogeneous second order differential equations: variation of parameters, method of undetermined coefficients. 5. To learn matrix methods for solving system of first order ordinary differential equations. Learning outcomes: ➢ To know different types of first order ODE and its applications. ➢ To learn second order ODE, Wronskian, linear independence of solutions. ➢ To understand homogeneous second order ODE, complementary function and particular integral. ➢ To understand phase plane, trajectory and phase portrait of a linear system.

Semester III (PRACTICALS)		**L**	**Cr**
Practical-I: **Calculus –III, Algebra-III, and Numerical Methods**	**Paper Code: RJSUMATP301**		**3**
1	Calculation of upper and lower sums. Problems based on definition of Riemann integral, Riemann criterion, and examples of non-Riemann integrable functions.		
2	Problems based on fundamental theorems of calculus, mean value theorems, Leibnitz rule.		
3	Problems based on Convergence and divergence of infinite series.		
4	Problems based on Leibniz test, absolute and conditional convergence.		
5	Problems based on improper integrals.		
6	Problems based on beta and gamma functions.		
7	Miscellaneous theoretical questions based on three units of Calculus-III		
8	Examples of vector spaces, Subspaces.		
9	Linear span, Linearly dependent and Linearly Independent Set of a vector space.		
10	Basis and Dimension of Vector Space.		
11	Extending basis, row/column space of a matrix.		
12	Linear Transformation, rank and nullity of a linear transformation.		
13	Associated matrices, Linear isomorphism.		

14	Miscellaneous theoretical questions based on three units of Algebra-III		
15	Problems on measure of errors, bisection method and Newton-Raphson method.		
16	Problems on secant method, Regula-Falsi method, and fixedpoint iteration.		
17	Problems on finite difference operators, finite difference tables.		
18	Problems on Lagrange's, Newton's and Stirling's interpolations.		
19	Problems on numerical differentiation.		
20	Problems on numerical integrations.		
21	Miscellaneous theoretical questions based on three units of Numerical Methods.		

S.Y.BSc	Practicals Semester III
RJSUMATP301 Practical I	Course Outcomes: 1. To apply definition of integration to find integral of certain functions. 2. Problems based on improper integrals and beta, gamma functions. 3. Checking a set to be a vector space/subspace. 4. Checking a set to be linearly dependent/independent. 5. To find roots of algebraic and transcendental equations. 6. To use interpolation to compute derivatives and integrations Learning outcomes: ➢ To understand the concept of integration thoroughly. ➢ To understand infinite series and improper integrals through examples. ➢ Finding linear span of a set, basis and dimension of a real vector space. ➢ Finding rank, nullity and associated matrix of a linear transformation. ➢ To be able to use bisection method, Newton-Raphson method, Secant method to approximate a root of an equation. ➢ To be able to implement interpolation and Newton-Cotes formulae to finding derivatives and integration values approximately.

Semester IV (PRACTICALS)		**L**	**Cr**
Practical-II: Multivariable Differential Calculus, Algebra-IV, and Differential Equations	**Paper Code: RJSUMATP401**		**3**
1	Problems based on open sets, sequences, limits and continuity of scalar fields and vector fields		
2	Problems based on directional derivatives, partial derivatives, and Mean value theorem		
3	Problems based on total derivative of scalar fields, chain rules, and Euler's theorem for homogeneous functions		
4	Problems based on total derivative of vector fields, Jacobian matrix, and chain rule for derivative of vector fields		
5	Problems based on level sets, tangent planes, linear and quadratic approximations, and Hessian matrix		
6	Problems based on extreme values, saddle points, and method of Lagrange's multipliers		
7	Miscellaneous theoretical questions based on three units of Multivariable Differential Calculus		
8	Inner product spaces, examples. Orthogonal complements in $\mathbb{R}^2$and $\mathbb{R}^3$		
9	Orthogonal/orthonormal sets, Gram-Schmidt method		
10	Quotient Spaces, Orthogonal Transformations		
11	Cayley Hamilton Theorem and Applications		
12	Eigen Values & Eigen Vectors of a linear Transformation/ Square Matrices		
13	Similar Matrices, Diagonalisation of a matrix		
14	Miscellaneous Theoretical Questions based on three units of Algebra-IV		
15	Solving exact and non-exact ODEs		

16	Linear and reducible to linear equations, applications to ODEs		
17	Solving homogeneous second order linear differential equations		
18	Solving nonhomogeneous second order linear differential equations		
19	Solving homogeneous system of linear ODEs		
20	Solving nonhomogeneous system of linear ODEs		
21	Miscellaneous Theoretical Questions based on three units of Differential Equations		

S.Y.B.Sc	Semester IV
RJSUMATP401 Practical - I	Course Outcomes: 1. Problems based on limit and continuity of multivariable functions. 2. Finding derivatives of multivariable functions. 3. Finding orthogonal complement of a set.Checking of a set to be orthogonal/orthonormal set. 4. Finding basis and dimension of Quotient spaces.Finding eigen values and eigen vectors of an endomorphism/square matrix. 5. To implement various methods to solve first order and second order differential equations. 6. Problems based on linear system of first order differential equations. Learning outcomes: ➢ To learn basic concepts of calculus for scalar and vector fields through examples. ➢ To learn applications of differentiation of multivariable functions. ➢ Checking whether two matrices are similar. ➢ Check whether an endomorphism/square matrix is diagonalizable. ➢ To be able to solve problems on orthogonal trajectories, carbon dating, L-R circuits. ➢ To be able to solve homogeneous and nonhomogeneous second order linear differential equations.

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41. A. K. Nandakumaran, P. S. Datti, R. K. George, Ordinary Differential Equations Principles and Applications, Cambridge University Press, New Delhi, 2017.

Scheme of Examination

1. There will be theory examination of 100 marks for each of the coursesRJSUMAT301, RJSUMAT302, RJSUMAT303 and practical examination of 150marks for course RJSUMATP301 of semester III and theory examination of100 marks for each of the courses RJSUMAT401, RJSUMAT402, RJSUMAT403 and practical examination of 150 marks for courseRJSUMATP401 of semester IV. Passing in theory and practical shall be separate.
2. Passing percentage is 40 percent.
3. In Theory Examination

(i) There will be two Internal Assessments each of 20 marks and semester end examination of 60 marks for each of the courses RJSUMAT301,RJSUMAT302, RJSUMAT303 of semester III and RJSUMAT401, RJSUMAT402,RJSUMAT403 of semester IV.
(ii) There will be combined passing (20+20+60=100 marks)
(iii) Students have to compulsorily attempt Semester end examination and at least one Internal Assessment.

Internal Assessments: There will be two Internal Assessment each of 20 marks for each of the courses RJSUMAT301, RJSUMAT302, RJSUMAT303 of semester III and RJSUMAT401, RJSUMAT402, RJSUMAT403 of semester IV. Internal Assessment I and II pattern:
(a) Objective type (five out of seven) (2X5=10 marks)
(b) Problems (two out of three) (5x2=10)

Semester End Theory Examinations: There will be a Semester end theory examination of 60 marks for each of the courses RJSUMAT301,RJSUMAT302, RJSUMAT303 of semester III and RJSUMAT401, RJSUMAT402,RJSUMAT403 of semester IV.
1. Duration: The examinations shall be of 2 Hours duration.
2. Theory Question Paper Pattern:

a) There shall be three questions Q1, Q2, Q3 each of 20 marks and each based on the units 1, 2, 3 respectively.
b) All the questions shall be compulsory. The questions Q1, Q2, Q3 shall have internal choices within the questions. Including the choices, the marks for each question shall be 40.
c) Each of the questions Q1, Q2, Q3 will be subdivided into two sub-questions as follows:
(i) Attempt any one out of two questions (each of 8 marks)
(ii) Attempt any two out of four questions (each of 6 marks)

Semester End Practical Examinations:
At the end of the Semesters III & IV Practical examinations of three hours duration and 150 marks shall be conducted for the courses RJSUMATP301, RJSUMATP401of semester III and IV respectively.

Paper pattern: The question paper shall have three parts A and B.
Each part shall have two Sections.
Section I Objective in nature: Attempt any Eight out of Twelve multiple choice questions. (8 x 2 = 16 Marks)
Section II Problems: Three questions based on each unit with internal choices. (3x8 = 24 Marks)

Practical Course	Part A	Part B	Part C	Marks out of	Duration
RJSUMATP301	Questions from RJSUMAT301	Questions from RJSUMAT302	Questions from RJSUMAT303	120	3 hrs.
RJSUMATP401	Questions from RJSUMAT401	Questions from RJSUMAT402	Questions from RJSUMAT403	120	3 hrs.

Marks for Journals:

For each course RJSUMAT301, RJSUMAT302, RJSUMAT303, RJSUMAT401,RJSUMAT402, RJSUMAT403:

Journals: 10 marks.

Each Practical of every course of Semester III and IV shall contain 10 (ten) problems out of which minimum 05 (five) have to be written in the journal. A student must have a certified journal before appearing for the practical examination.