Hindi Vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College

of Arts, Science & Commerce

(Autonomous College)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for the T.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

T.Y.B.Sc. MATHEMATICS SEMESTER V

Course	Nomenclature	Credits	Topics
RJSUMAT501	Multivariable Calculus and Analysis	2.5	1. Line Integrals 2. Surface Integrals 3. Sequence and Series of Functions
RJSUMAT502	Algebra-V	2.5	4. Quotient Spaces and Orthogonal Linear Transformations 5. Eigenvalues and eigen vectors 6. Diagonalisation
RJSUMAT503	Topology of Metric Spaces-I	2.5	7. Metric spaces and open sets in metric spaces 8. Closed sets and sequences in a metric space 9. Completeness and consequences of nested interval theorem
RJSUMAT504A	Number Theory and its Applications-I (Elective A)	2.5	10. Congruences and Factorization 11. Diophantine equations and their solutions 12. Primitive Roots and Cryptography
RJSUMAT504B	Numerical Analysis-I (Elective B)	2.5	13. Error Analysis 14. Transcendental and Polynomial equations

			15. Linear Systems of Equations
RJSUMATP501	Practical I	03	Line Integrals, Surface Integrals, Sequence and Series of Functions, Quotient Spaces and Orthogonal Linear Transformations, Eigenvalues and eigen vectors, Diagonalisation,
RJSUMATP502	Practical II	03	Metric spaces and open sets in metric spaces, Closed sets and sequences in a metric space, Completeness and consequences of nested interval theorem, A) Congruences and Factorization, Diophantine equations and their solutions, Primitive Roots and Cryptography. B) Error Analysis, Transcendental and Polynomial equations, Linear Systems of Equations.

T.Y.B.Sc. MATHEMATICS SEMESTER VI

Course	Nomenclature	Credits	Topics
RJSUMAT601	Complex Analysis	2.5	1. Analytic Functions 2. Complex Integration 3. Complex Power Series
RJSUMAT602	Algebra-VI	2.5	4. Group Theory 5. Ring Theory 6. Polynomial Rings and Field theory
RJSUMAT603	Topology of Metric Spaces-II	2.5	7. Compact sets 8. Continuous functions on metric spaces 9. Connected Sets
RJSUMAT604A	Number Theory and its Applications-II (Elective A)	2.5	10. Quadratic Reciprocity 11. Continued Fractions 12. Arithmetic function and Special numbers
RJSUMAT604B	Numerical Analysis-II (Elective B)	2.5	13. Interpolations 14. Polynomial Approximations and Numerical Differentiation 15. Numerical Integration
RJSUMATP601	Practical I	03	Analytic Functions, Complex Integration, Complex Power Series, Group Theory, Ring Theory, Polynomial Rings and Field theory.
RJSUMATP602	Practical II	03	Compact sets, Continuous functions on metric spaces, Connected Sets. A) Quadratic Reciprocity,

			Continued Fractions, Arithmetic function and Special numbers. B) Interpolations, Polynomial Approximations and Numerical Differentiation, Numerical Integration.

Note:
1. RJSUMAT501, RJSUMAT502, RJSUMAT503 are compulsory courses for Semester V.
2. Candidate has to opt one Elective Course from RJSUMAT504A/ RJSUMAT504B.
3. RJSUMAT601, RJSUMAT602, RJSUMAT603 are compulsory courses for Semester VI.
4. Candidate has to opt one Elective Course from RJSUMAT604A/ RJSUMAT604B.

			L	Cr
SEMESTER V (THEORY)			**L**	**Cr**
Paper-I: Multivariable Calculus and Analysis		**Paper Code:** RJSUMAT501	45	2.5
UNIT I			15	
LINE INTEGRALS				
1	Vector differential operators, gradient, curl, divergence, elementary identities involving gradient, curl and divergence. Paths (parametrized curves) in $\mathbb{R}^n$ (emphasis on $\mathbb{R}^2$ and $\mathbb{R}^3$), smooth and piecewise smooth paths, closed paths, equivalence and orientation preserving equivalence of paths. Definition of the line integral of scalar fields as well as vector fields over a piecewise smooth path, basic properties of line integrals including linearity, path-additivity and behavior under a change of parameters. Line integrals of the gradient vector field, Fundamental Theorem of Calculus for Line Integrals. Necessary and sufficient conditions for a vector field to be conservative, Green's theorem and its applications to evaluation of line integrals.			
UNIT II			15	
SURFACE INTEGRALS				
1	Parametric representation of surfaces, Fundamental vector product-its definition and it being normal to the surface, area of parametric surfaces, definition of surface integrals of scalar fields as well as of vector fields defined on a surface. Stoke's theorem (proof assuming the general form of Green's theorem), examples. Gauss' divergence theorem (proof only in the case of cubical domains), examples.			
UNIT III			15	
SEQUENCE AND SERIES OF FUNCTIONS				
1	Sequence of functions - pointwise and uniform convergence of sequences of real-valued functions. Series of functions, convergence of series of functions, Weierstrass M-test, examples. Properties of uniform convergence: Continuity of the uniform limit of a sequence of continuous functions, conditions under which integral and the derivative of sequence of functions converge to the integral and derivative of uniform limit on a closed and bounded interval, consequences of these properties for series of functions, term by term differentiation and integration.			
2	Power series in $\mathbb{R}$ centered at origin and at some point in $\mathbb{R}$, radius of convergence, region (interval) of convergence, uniform convergence,			

	term by-term differentiation and integration of power series, uniqueness of series representation, functions represented by power series, classical functions defined by power series such as exponential, cosine and sine functions and basic properties of these functions.		

T.Y.BSc	Semester V Theory : Multivariable Calculus and Analysis
RJSUMAT501 Paper I Multivariable Calculus and Analysis	Course Outcomes5.1 : 1. To define line integrals of scalar and vector fields, basic properties and conservative of vector field 2. To learn Fundamental Theorems of Calculus for line integrals, Green's theorem and their applications 3. To understand the concept of surface integrals for scalar and vector fields and some identities involving gradient, curl and divergence 4. To study two important theorems viz. Stoke's thereom and Gauss divergence theorem and examples 5. To study pointwise and uniform convergence of sequence and series of functions 6. To learn the consequence of uniform convergence on limit functions 7. To introduce the concept of power series and representation of elementary functions Learning outcomes: ➢ Study of Line integral of scalar and vector fields ➢ Surface area, surface integrals of scalar and vector fields, understanding relations between line integral, surface integral and double and triple integrals ➢ Learning of sequence and series of functions and their consequences on continuity, differentiability and integrability.

		L	Cr
	SEMESTER V (THEORY)	**L**	**Cr**
	Paper-II: Algebra-V — **Paper Code:** RJSUMAT502	45	2.5
	UNIT I	15	
	QUOTIENT SPACES AND ORTHOGONAL LINEAR TRANSFORMATIONS		
1	Review of vector spaces over $\mathbb{R}$, sub spaces and linear transformation		
2	Quotient Spaces: For a real vector space V and a subspace W , the cosets $v + W$ and the quotient space V/W , First Isomorphism theorem of real vector spaces (fundamental theorem of homomorphism of vector spaces), Dimension and basis of the quotient space V/W when V is finite dimensional		
3	Orthogonal transformations: Isometries of a real finite dimensional inner product space, Translations and Reflections with respect to a hyperplane, Orthogonal matrices over $\mathbb{R}$, Equivalence of orthogonal transformations and isometries fixing origin on a finite dimensional inner product space, Orthogonal transformation of $\mathbb{R}^2$, Any orthogonal transformation in $\mathbb{R}^2$ is a reflection or a rotation, Characterization of isometries as composites of orthogonal transformations and translation. Characteristic polynomial of an $n \times n$ real matrix. Cayley Hamilton Theorem and its Applications (Proof assuming the result A(adjA) = I_n for an $n \times n$ matrix over the polynomial ring $\mathbb{R}[t]$).		
	UNIT II	15	
	EIGENVALUES AND EIGEN VECTORS		
1	Eigen values and eigen vectors of a linear transformation T: $V \to V$, where V is a finite dimensional real vector space and examples, Eigen values and Eigen vectors of $n \times n$ real matrices, The linear independence of eigenvectors corresponding to distinct eigenvalues of a linear transformation. The characteristic polynomial of an nxn real matrix and a linear transformation of a finite dimensional real vector space to itself, characteristic roots, Similar matrices, Relation with change of basis, Invariance of the characteristic polynomial and (hence of the) eigenvalues of similar matrices, Every square matrix is similar to an upper triangular matrix. Minimal Polynomial of a matrix, Examples like minimal polynomial of scalar matrix, diagonal matrix, similar matrix, Invariant subspaces		

	UNIT III	15	
	DIAGONALISATION		
1	Geometric multiplicity and Algebraic multiplicity of eigen values of an $n \times n$ real matrix, An $n \times n$ matrix A is diagonalizable if and only if it has a basis of eigenvectors of A if and only if the sum of dimension of eigen spaces of A is n if and only if the algebraic and geometric multiplicities of eigen values of A coincide, Examples of non diagonalizable matrices, Diagonalisation of a linear transformation $T: V \to V$, where V is a finite dimensional real vector space and examples. Orthogonal diagonalisation and Quadratic Forms. Diagonalisation of real Symmetric matrices, Examples, Applications to real Quadratic forms, Rank and Signature of a Real Quadratic form, Classification of conics in $\mathbb{R}^2$ and quadric surfaces in $\mathbb{R}^3$. Positive definite and semi definite matrices, Characterization of positive definite matrices in terms of principal minors.		

T.Y.BSc	Semester V Theory : Algebra-V
RJSUMAT502 Paper II Algebra-V	Course Outcome 5.2 : 1. Quotient spaces and Isomorphism of real vector spaces. 2. Orthogonal transformations ,Isometries, Characteristic polynomials and Cayley Theorm. 3. Eigen values and eigen vectors, similar matrices . 4. Diagonalisation of a matrix with respect to eigen values/eigen vectors. 5. Quadratic forms. Learning Outcome : ➢ Application of First, second and Third Isomorphism theorem , cayley theorem. ➢ Deatailed study of similar matrices and its relation with change of basis. ➢ Applications of Quadratic form.

SEMESTER V (THEORY)		L	Cr
Paper-III: Topology of Metric Spaces-I	**Paper Code:** RJSUMAT503	45	2.5
UNIT I		15	
METRIC SPACES, OPEN BALLS AND OPEN SETS IN METRIC SPACES			
1	Definition, examples of metric spaces $\mathbb{R}$; $\mathbb{R}^2$, Euclidean space $\mathbb{R}^n$ with its Euclidean, sup and sum metric, $\mathbb{C}$(complex numbers), the spaces ℓ^1, ℓ^2 and ℓ^∞ of sequences and the space C[a, b] of real valued continuous functions on [a, b]. Discrete metric space. Finite metric spaces. Normed linear spaces, distance metric induced by the norm.		
2	Metric subspaces, Product of two metric spaces. Open balls, closed balls, closed sets in a metric space, examples and properties. Hausdorff property. Interior of a set. Structure of an open set in $\mathbb{R}$, Equivalent metrics.		
UNIT II		15	
LIMIT POINTS OF A SET AND SEQUENCES IN A METRIC SPACE			
1	Limit point of a set, a closed set contains all its limit points, Closure of a set and boundary of a set. Distance of a point from a set, distance between two sets, diameter of a set in a metric space and bounded sets in a metric space.		
2	Definition and examples - Sequences, Convergent sequence, Cauchy sequence, and subsequences in metric space and properties.		
3	Characterization of limit points and closure points in terms of sequences. Dense subsets in a metric space and Separability.		
UNIT III		15	
COMPLETENESS AND CONSEQUENCES OF NESTED INTERVAL THEOREM			
1	Definition of complete metric spaces, examples of complete metric spaces, completeness property in subspaces, Cantor's Intersection Theorem, Nested Interval theorem in $\mathbb{R}$.		
2	Applications of Nested interval Theorem: (i) The set of real Numbers is uncountable. (ii) Density of rational Numbers (between any two real numbers there exists a rational number) (iii) Intermediate Value theorem for $\mathbb{R}$ (iv) Bolzano-Weierstrass theorem for $\mathbb{R}$ (v) Heine-Borel Theorem for $\mathbb{R}$		

T.Y.BSc	Theory Semester V : Topology of Metric Spaces-I
RJSUMAT503 paper III Topology of Metric Spaces-I	Course Outcome 5.3: 1. Metric spaces, normed spaces and examples 2. To learn open sets, closed sets, limit points of a set, closure of a set 3. Sequences in metric spaces and their properties 4. To study complete metric space and Nested Interval Theorem and its applications 5. Separability and dense subsets of metric spaces Learning Outcome : ➢ To understand Metric spaces, normed spaces ➢ Convergent and Cauchy sequences in metric spaces ➢ Completeness of metric space and consequences of Nested Interval Theorem

SEMESTER V (THEORY)		L	Cr
Paper-IV: Number Theory and its applications – I [Elective A]	**Paper Code: RJSUMAT504A**	45	2.5
UNIT I		15	
CONGRUENCES AND FACTORIZATION			
1	Review of Divisibility, Primes and the fundamental theorem of Arithmetic.		
2	Congruences, Complete residue system modulo m, Reduced residue system modulo m, Fermat's little Theorem, Euler's generalization of Fermat's little Theorem, Wilson's theorem, Linear congruences, Simultaneous linear congruences in two variables. The Chinese remainder Theorem, Congruences of Higher degree, The Fermat-Kraitchik Factorization Method.		
UNIT II		15	
DIOPHANTINE EQUATIONS AND THEIR SOLUTIONS			
1	The linear Diophantine equation ax + by = c. The equation $x^2+ y^2= z^2$, Primitive Pythagorean triple and its characterisation, The equations $x^4+ y^4= z^2$ and $x^4+y^4= z^4$ have no solutions (x; y; z) with $xyz\neq 0$. Fermat's two squares theorem, sum of three squares, Lagrange's four squares theorem.		
UNIT III		15	
PRIMITIVE ROOTS AND CRYPTOGRAPHY			
1	Order of an integer and Primitive Roots. Basic notions such as encryption (enciphering) and decryption (deciphering), Cryptosystems, symmetric key cryptography, Simple examples such as shift cipher, Affine cipher, Hill's cipher, Vigenere cipher, digraph transformations. Concept of Public Key Cryptosystem; RSA Algorithm, Digital Signatures, ElGamal Cryptosystem.		

<table>
<tr><td>T.Y.BSc</td><td>Theory Semester V : Number Theory and its applications – I [Elective A]</td></tr>
<tr><td>RJSUMAT501A
Paper IV
Number Theory and its applications – I [Elective A]</td><td>Course Outcome 5.4A:
1. To understand applications of Fermat's theorem, Euler's theorem, Wilson's theorem
2. To understand applications of Chinese remainder theorem and methods of factorization
3. To learn use of primes and congruences in the field of Cryptography
4. To understand concepts of primitive roots.
5. To learn solvability of Pythagorean triples and linear non linear Diophantine equations
6. To learn concept of expressing a natural number as a sum of two squares, three squares and four squares.

Learning Outcome :
1. To be able to implement elementary methods of cryptography
2. Should be able to handle higher power in integers
➢ Understanding of classical problems in number theory</td></tr>
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SEMESTER V (THEORY)			**L**	**Cr**
Paper-IV: Numerical Analysis – I [Elective B]		**Paper Code: RJSUMAT504B**	45	2.5
UNIT I			15	
ERRORS ANALYSIS AND TRANSCENDENTAL & POLYNOMIAL EQUATIONS				
1	Measures of Errors: Relative, absolute and percentage errors. Types of errors: Inherent error, Round-off error and Truncation error. Taylors series example. Significant digits and numerical stability. Concept of simple and multiple roots. Iterative methods, error tolerance, use of intermediate value theorem. Iteration methods based on first degree equation: Newton-Raphson method, Secant method, Regula-Falsi method, Iteration Method. Condition of convergence and Rate of convergence of all above methods.			
UNIT II			15	
TRANSCENDENTAL AND POLYNOMIAL EQUATIONS				
1	Iteration methods based on second degree equation: Muller method, Chebyshev method, Multipoint iteration method. Iterative methods for polynomial equations; Descarts rule of signs, Birge-Vieta method, Bairstrow method. Methods for multiple roots. Newton-Raphson method.			
2	System of non-linear equations by Newton- Raphson method. Methods for complex roots. Condition of convergence and Rate of convergence of all above methods.			
UNIT III			15	
LINEAR SYSTEM OF EQUATIONS				
1	Matrix representation of linear system of equations. Direct methods: Gauss elimination method.			
2	Pivot element, Partial and complete pivoting, Forward and backward substitution method, Triangularization methods-Doolittle and Crouts method, Choleskys method. Error analysis of direct methods. Iteration methods: Jacobi iteration method, Gauss-Siedal method. Convergence analysis of iterative method. Eigen value problem, Jacobis method for symmetric matrices Power method to determine largest eigenvalue and eigenvector.			

T.Y.B.Sc.	Semester V Theory Numerical Analysis – I [Elective B]
RJSUMAT504B Paper IV Numerical Analysis – I	Course Outcome 5.4B: 1. To understand Newton-Raphson method, Secant method, Regula-Falsi method, and their rate of convergence. 2. To learn Iteration methods: Muller method, Chebyshev method, Multipoint iteration method and their rate of convergence 3. To learn Doolittle and Crouts method, Choleskys method, Jacobi iteration method, Gauss-Siedal method and convergence analysis Learning Outcome : 1. To understand various types of errors and their sources 2. To learn methods of finding approximate roots of an equation 3. To learn methods of finding solutions of simultaneous linear equations

SEMESTER VI (THEORY)			**L**	**Cr**
Paper-I: Complex Analysis		**Paper Code: RJSUMAT601**	45	2.5
UNIT I			15	
ANALYTIC FUNCTIONS				
1	Review of complex numbers: Complex plane, polar coordinates, exponential map, powers and roots of complex numbers, De Moivre's formula, $\mathbb{C}$ as a metric space, bounded and unbounded sets, point at infinity-extended complex plane, sketching of a set in complex plane (No questions to be asked).			
2	Limit at a point, theorems on limits, convergence of sequences of complex numbers and results using properties of real sequences, functions from $\mathbb{C}$ to $\mathbb{C}$, real and imaginary part of functions, continuity at a point and algebra of continuous functions, derivative of $f: \mathbb{C} \rightarrow \mathbb{C}$; comparison between differentiability in real and complex sense, Cauchy-Riemann equations, sufficient conditions for differentiability, analytic function, and algebra of analytic functions, chain rule, harmonic functions and harmonic conjugate.			
UNIT II			15	
COMPLEX INTEGRATION				
1	Exponential function and its properties, trigonometric functions, hyperbolic functions, Mobius transformations.			
2	Evaluating the line integral $\int f(z)dz$ over $\|z - z_0\| = r$, The Cauchy integral formula, Cauchy integral theorem, consequences of the Cauchy integral formula, derivative of analytic functions, Liouville's theorem, Application to the Fundamental Theorem of Algebra, Maximum modulus theorem.			
UNIT III			15	
COMPLEX POWER SERIES				
1	Taylor's theorem for analytic functions, power series of complex numbers and related results, radius of convergence, disc of convergence, uniqueness of series representation, Laurent series, definition of isolated singularity, type of isolated singularities viz. removable, pole and essential defined using Laurent series expansion, Cauchy residue theorem and calculation of residue, applications of residues.			

T.Y.B.Sc.	Semester V Theory: Complex Analysis
RJSUMAT601 Paper I Complex Analysis	Course Outcome 6.1: 1. To study Limit and continuity, differentiability and analyticity of complex functions 2. To study elementary functions in complex plane and transformations 3. To evaluate complex integration using Cauchy integral formula 4. To learn power series of complex numbers including Taylor's series and Laurent's series and different types of singularities 5. To compute residues and its applications Learning Outcome : ➢ To be able to identify complex differentiability, analyticity of complex functions using definition and C-R equations ➢ Cauchy theory of complex integration and its applications ➢ To understand complex power series and types of singularities

SEMESTER VI (THEORY)			L	Cr
Paper-II: ALGEBRA-VI		Paper Code: RJSUMAT602	45	2.5
UNIT I			15	
GROUP THEORY				
1	Review of Groups , Subgroups, Abelian groups, Order of a group, Finite and infinite groups, Cyclic groups, The Center $Z(G)$ of a group G. Cosets, Lagranges theorem, Group homomorphisms, isomorphisms, automorphisms, inner automorphisms (No questions to be asked).			
2	Normal subgroups: Normal subgroups of a group, definition and examples including center of a group, Quotient group, Alternating group A_n, Cycles. Listing normal subgroups of A_4, S_3. First Isomorphism theorem (or Fundamental Theorem of homomorphisms of groups), Second Isomorphism theorem, third Isomorphism theorem, Cayley's theorem, External direct product of a group, Properties of external direct products, Order of an element in a direct product, criterion for direct product to be cyclic, Classification of groups of order ≤ 7.			
UNIT II			15	
RING THEORY				
1	Motivation: Integers & Polynomials.			
2	Definitions of a ring (The definition should include the existence of a unity element), zero divisor, unit, the multiplicative group of units of a ring. Basic Properties & examples of rings, including $\mathbb{Z}, \mathbb{Q}, \mathbb{R}, \mathbb{C}, M_n(\mathbb{R}), \mathbb{Q}[X], \mathbb{R}[X], \mathbb{C}[X], \mathbb{Z}[i], \mathbb{Z}[\sqrt{-5}], \mathbb{Z}_n$.			
3	Definitions of Commutative ring, integral domain (ID), Division ring, examples. Theorem such as: A commutative ring R is an integral domain if and only if for $a, b, c \in R$ *with* $a \neq 0$ the relation $ab = ac$ implies that $b = c$. Definitions of Subring, examples. Ring homomorphisms, Properties of ring homomorphisms, Kernel of a ring homomorphism, Ideals, Operations on ideals and Quotient rings, examples. Factor theorem, First and second Isomorphism theorems for rings, Correspondence Theorem for rings: If $f : R \rightarrow R'$ is a surjective ring homomorphism, then there is a 1-1 correspondence between the ideals of R containing the ker(f) and the ideals of R'. Definitions of characteristic of a ring, Characteristic of an ID.			

UNIT III		15	
POLYNOMIAL RINGS AND FIELD THEORY			
1	Principal ideal, maximal ideal, prime ideal, characterization of the prime and maximal ideals in terms of quotient rings. Polynomial rings, R[X] when R is an integral domain/field. Divisibility in an Integral Domain, Definitions of associates, irreducible and primes. Prime (irreducible) elements in $\mathbb{R}[X], \mathbb{Q}[X]$; $\mathbb{Z}_p[X]$. Eisenstein's criterion for irreducibility of a polynomial over $\mathbb{Z}$. Prime and maximal ideals in polynomial rings. Definition of field, subfield and examples, characteristic of fields. Any field is an ID and a finite ID is a field. Characterization of fields in terms of maximal ideals, irreducible polynomials. Construction of quotient field of an integral domain (Emphasis on $\mathbb{Z}, \mathbb{Q}$). A field contains a subfield isomorphic to $\mathbb{Z}_p$ or $\mathbb{Q}$.		

T.Y.B.Sc.	Semester VI Theory : Algebra VI
RJSUMAT602 Paper II Algebra VI	Course Outcome 6.2: 1. Normal groups, Quotient groups and Isomorphism theorems of groups. External direct product of groups 2. Ring theory ,Isomorphism theorem for Rings. 3. Ideals 4. Quotient Field. Learning Outcome : ➢ Using Isomorphism to classify groups of orders ≤ 7 ➢ Understanding of Integral Domain and Division Ring. ➢ Developing the concept of different type of Ideals in ➢ Rings ➢ Learn to construct a quotient field

SEMESTER VI (THEORY)			**L**	**Cr**
Paper-III: Topology of Metric Spaces-II		**Paper Code: RJSUMAT603**	45	2.5
UNIT I			15	
COMPACT SETS				
1	Definition of compact metric space using open cover, examples of compact sets in different metric spaces, sequentially compact metric space, Bolzano-Weierstrass property. Properties of compact sets: A compact set is closed and bounded, (Converse is not true). Every infinite bounded subset of compact metric space has a limit point. A compact set has Bolzano-Weierstrass property. A compact set is sequentially compact. A closed subset of a compact set is compact. Union and Intersection of Compact sets. Equivalent statements for compact sets in $\mathbb{R}^n$: Sequentially compactness property, Heine-Borel property, closed and boundedness property. Bolzano-Weierstrass property.			
UNIT II			15	
CONTINUOUS FUNCTIONS ON METRIC SPACES				
1	Epsilon-delta definition of continuity at a point of a function from one metric space to another. Characterization of continuity at a point in terms of sequences, open sets and closed sets and examples, Algebra of continuous real valued functions on a metric space. Continuity of composite continuous function. Continuous image of compact set is compact, uniform continuity in a metric space, definition and examples (emphasis on $\mathbb{R}$). Let (X, d) and (Y, d') be metric spaces and f: X → Y be continuous, where (X, d) is a compact metric space, then f: X→Y is uniformly continuous. Contraction mapping and fixed point theorem, Applications.			
UNIT III			15	
CONNECTED SETS				
1	Separated sets- Definition and examples, disconnected sets, disconnected and connected metric spaces, connected subsets of a metric space, Connected subsets of $\mathbb{R}$. A subset of $\mathbb{R}$ is connected if and only if it is an interval. A continuous image of a connected set is connected. Characterization of a connected space, viz. a metric space is connected if and only if every continuous function from X to {1, -1} is a constant function. Path connectedness in $\mathbb{R}^n$, definition and examples.			

	A path connected subset of $\mathbb{R}^n$ is connected, convex sets are path connected. Connected components. An example of a connected subset of $\mathbb{R}^n$ which is not path connected.		

T.Y.B.Sc.	Semester VI Theory: Topology of Metric Spaces-II
RJSUMAT603 Paper III Topology of Metric Spaces-II	Course Outcome 6.3: 1. To study compactness in metric spaces 2. To study compactness in Euclidean space 3. To learn important properties of compactness 4. To study continuous functions in metric spaces using $\varepsilon - \delta$ definition as well as in terms of sequence 5. Contraction mapping and fixed point theorem 6. connected metric spaces, path connectedness Learning Outcome : ➢ Compact metric space and its properties ➢ Continuous functions in metric spaces ➢ Connected and disconnected subsets and their characterization

			L	Cr
SEMESTER VI (THEORY)			**L**	**Cr**
Paper-IV: Number Theory and Its applications – II [Elective A]		**Paper Code: RJSUMAT604A**	45	2.5
UNIT I			15	
QUADRATIC RECIPROCITY				
1	Quadratic residues and Legendre Symbol, Gauss' Lemma, Theorem on Legendre Symbols $(\frac{-1}{p})$ and $(\frac{2}{p})$, Quadratic Reciprocity law and its applications, The Jacobi Symbol and law of reciprocity for Jacobi Symbol. Quadratic Congruences with Composite moduli.			
UNIT II			15	
CONTINUED FRACTIONS				
1	Finite continued fractions. Infinite continued fractions and representation of an irrational number by an infinite simple continued fraction, Rational approximations to irrational numbers and order of convergence, Best possible approximations. Periodic continued fractions. Pell's equations and their solutions.			
UNIT III			15	
ARITHMETIC FUNCTION AND SPECIAL NUMBERS				
1	Arithmetic functions of number theory: $\tau(n)$, $\sigma(n)$, $\sigma_s(n)$, $\omega(n)$, $\varphi(n)$ and their properties, $\mu(n)$ and the Mobius inversion formula.			
2	Special numbers: Fermat numbers, Mersenne numbers, Perfect numbers, Amicable numbers, Pseudoprimes, Carmichael numbers.			

T.Y.B.Sc.	Semester VI Theory : Number Theory and Its applications – II
RJSUMAT6034A Paper IV Number Theory and Its applications – II	Course Outcome 6.4A: 1. To understand use concepts and uses of finite continued fractions 2. To learn relation between irrational numbers and infinite continued fractions 3. Solving quadratic congruence using Legendre and Jacobi symbols 4. To understand number theoretic functions such as sigma, tau, Euler's 5. To learn special numbers such as Fermat numbers, Amicable numbers, perfect numbers and Messene numbers. Learning Outcome : ➢ To understand that better approximations of irrational numbers can be done through continued fractions ➢ To know Pell's equation and role of continued fractions in its solution. ➢ To be able to solve quadratic congruences through the help of quadratic reciprocity law.

SEMESTER VI (THEORY)			L	Cr
Paper-IV: Numerical Analysis – II [Elective B]		**Paper Code: RJSUMAT604B**	45	2.5
UNIT I			15	
INTERPOLATION				
1	Interpolating polynomials, Uniqueness of interpolating polynomials. Linear, Quadratic and Higher order interpolation. Lagrange's Interpolation. Finite difference operators: Shift operator, forward, backward and central difference operator, Average operator and relation between them.			
2	Difference table, Relation between difference and derivatives. Interpolating polynomials using finite differences Gregory-Newton forward difference interpolation, Gregory-Newton backward difference interpolation, Stirling's Interpolation. Results on interpolation error.			
UNIT II			15	
POLYNOMIAL APPROXIMATIONS AND NUMERICAL DIFFERENTIATION				
1	Piecewise Interpolation: Linear, Quadratic and Cubic. Bivariate Interpolation: Lagrange's Bivariate Interpolation, Newton's Bivariate Interpolation. Numerical differentiation: Numerical diferentiation based on Interpolation, Numerical differentiation based on finite differences (forward, backward and central), Numerical Partial differentiation.			
UNIT III			15	
NUMERICAL INTEGRATION				
1	Numerical Integration based on Interpolation. Newton-Cotes Methods, Trapezoidal rule, Simpson's 1/3rd rule, Simpson's 3/8th rule. Determination of error term for all above methods..			
2	Convergence of numerical integration: Necessary and sufficient condition (with proof). Composite integration methods; Trapezoidal rule, Simpson's rule.			

T.Y.B.Sc.	Semester VI Theory : Numerical Analysis – II
RJSUMAT6034B Paper IV Numerical Analysis – II	Course Outcome 6.4B: 1. To learn Lagrange's Interpolation formula, Newton's forward and backward interpolating formulae 2. To learn Newton's and Lagrange's bivariate interpolation formulae 3. To learn Trapezoidal rule, Simpson's $1/3^{rd}$ and Simpson's $3/8^{th}$ rule and their convergence Learning Outcome : ➢ To learn methods of interpolation ➢ To understand numerical differentiation through polynomial approximations ➢ To know methods of computing definite integrals

			L	Cr
Semester V (PRACTICALS)				
Practical-I: **Multivariable Calculus and Analysis, Algebra-V**		**Paper Code: RJSUMATP501**		**3**
1	Line integrals of scalar and vector fields			
2	Green's theorem, conservative field and applications			
3	Evaluation of surface integrals			
4	Stokes and Gauss divergence theorem			
5	Pointwise and uniform convergence of sequence of functions			
6	Pointwise and uniform convergence of series of functions			
7	Miscellaneous theoretical questions based on three units of Multivariable Calculus and Analysis			
8	Quotient Spaces, Orthogonal Transformations			
9	Cayley Hamilton Theorem and Applications			
10	Eigen Values & Eigen Vectors of a linear Transformation/ Square Matrices			
11	Similar Matrices, Minimal Polynomial, Invariant Subspaces			
12	Diagonalisation of a matrix			
13	Orthogonal Diagonalisation and Quadratic Forms			
14	Miscellaneous theoretical questions based on three units of Algebra-V			

<table>
<tr><td>T.Y.B.Sc.</td><td>Semester V Practical :</td></tr>
<tr><td>RJSUMATP501
Practical-I

Multivariable Calculus and Analysis, Algebra-V</td><td>Course Outcome:
1. To compute line integrals of scalar and vector fields
2. To evaluate given integral using Green's theorem
3. To evaluate surface integrals
4. To examine pointwise and uniform convergence
5. Quotient Spaces, Orthogonal Transformations, Eigen values/vectors
6. Similar Matrices, Minimal Polynomial, Diagonalisation of a matrix and Quadratic Forms

Learning Outcome :
➢ To know elementary identities involving various operators
➢ Applications of Green's theorem
➢ Applications of Stoke's and divergence theorem
➢ To learn to classify pointwise and uniform convergence
➢ Learn to solve varieties of problems based on Quotient spaces, similar matrices, orthogonal diagonalisation of a matrix and quadratic forms etc. and able to co-relate among them.</td></tr>
</table>

Semester V (PRACTICALS)		L	Cr
Practical-II: **Topology of Metric Spaces-I , Number Theory and its applications – I OR Numerical Analysis – I**	**Paper Code: RJSUMATP502**		**3**
1	Example of metric spaces, normed linear spaces		
2	Sketching of open balls in $\mathbb{R}^2$ and open sets in metric spaces/ normed linear spaces, interior of a set, subspaces		
3	Closed sets, sequences in a metric space		
4	Limit points, dense sets, separability, closure of a set, distance between two sets.		
5	Complete metric space		
6	Cantor's Intersection theorem and its applications		
7	Miscellaneous theoretical questions based on three units of Topology of Metric Spaces-I		
8	Fermat's theorem, Wilson's theorem, Euler's theorem		
9	Chinese remainder theorem, linear and higher order congruences, factorization		
10	Linear Diophantine equations		
11	Pythagorean triples, sum of two squares, three squares, four squares		
12	Primitive roots, shift cipher, affine cipher, Hill cipher		
13	Vigenere Cipher, Digraph transformations, Public key cryptosystems		
14	Miscellaneous theoretical questions based on three units of Number Theory and its applications – I		

15	Newton-Raphson method, Secant method, Regula-Falsi method, Iteration Method		
16	Muller method, Chebyshev method, Multipoint iteration method		
17	Descarts rule of signs, Birge-Vieta method, Bairstrow method		
18	Gauss elimination method, Forward and backward substitution method		
19	Triangularization methods-Doolittles and Crouts method, Choleskys method		
20	Jacobi iteration method, Gauss-Siedal method		
21	Eigen value problem: Jacobis method for symmetric matrices and Power method to determine largest eigenvalue and eigenvector		

<table>
<tr><td>T.Y.B.Sc.</td><td>Semester V Practical</td></tr>
<tr><td>RJSUMATP502
Practical-II

Topology of Metric Spaces-I , Number Theory and its applications – I OR Numerical Analysis – I</td><td>Course Outcome:
1. To learn concept of metric space and normed spaces through examples
2. To understand sequence in metric spaces and its properties
3. To study various type of points in a metric space
4. To implement the Chinese Remainder Theorem, Fermat's theorem, Euler's theorem
5. To implement affine cipher, RSA cryptosystem, ElGamal cryptosystem
6. To use Newton Raphson method, secant method, multipoint iteration method

Learning Outcome :
➢ Completeness of metric spaces
➢ Geometric structure on vector spaces
➢ To be able to solve simultaneous linear congruences and polynomial congruences
➢ Finding primitive roots and its use in constructing Elgamal Cryptosystem
➢ Finding approximate roots of a polynomial and transcendental equations
➢ Finding approximate solutions of simultaneous linear equations</td></tr>
</table>

			L	Cr
Semester VI (PRACTICALS)				
Practical-I: **Complex Analysis, Algebra-VI**		**Paper Code: RJSUMATP601**		**3**
1	Limit and continuity and sequence of complex numbers			
2	Derivatives of complex functions , analyticity, harmonic functions			
3	Elementary functions and Mobius transformation			
4	Complex integration, Cauchy integral formula and Cauchy integral theorem			
5	Taylor's series, Laurent series and singularities			
6	Calculation of residues and applications			
7	Miscellaneous theoretical questions based on three units of Complex Analysis			
8	Normal Subgroups and quotient groups			
9	Cayleys Theorem and external direct product of groups			
10	Rings, Subrings, Ideals, Ring Homomorphism and Isomorphism			
11	Prime Ideals and Maximal Ideals			
12	Polynomial Rings			
13	Fields			
14	Miscellaneous theoretical questions based on three units of Algebra-VI			

T.Y.B.Sc.	Semester VI Practical
RJSUMATP601 Practical-I Complex Analysis, Algebra-VI	Course Outcome : 1. To solve problems based on limit, continuity and differentiability of complex functions 2. Study of analytic, harmonic functions through examples 3. To write power series of given function and to identify its singularities 4. Quotient groups, External Direct products ,Ring, Subrings, Ideals Learning Outcome : ➢ To be able to solve problems in complex analysis at elementary level ➢ Understanding and solving problems based on Quotient groups, Rings,different type of ideals and able to differentiate among them.

Semester VI (PRACTICALS)		**L**	**Cr**
Practical-II: **Topology of Metric Spaces-II , Number Theory and its applications – II, OR Numerical Analysis – II**	**Paper Code: RJSUMATP602**		**3**
1	Compact sets in various metric spaces		
2	Compact sets in $\mathbb{R}^n$		
3	Continuity in a metric space		
4	Uniform continuity, contraction maps, fixed point theorem		
5	Connectedness in metric spaces		
6	Path connectedness		
7	Miscellaneous theoretical questions based on three units of Topology of Metric Spaces-II		
8	Legendre Symbol, Gauss' Lemma, quadratic reciprocity law		
9	Jacobi Symbol, quadratic congruences with prime and composite moduli		
10	Finite and infinite continued fractions		
11	Approximations and Pell's equations		
12	Arithmetic functions of number theory		
13	Special numbers		
14	Miscellaneous theoretical questions based on three units of Number Theory and its applications – II		

15	Linear, Quadratic and Hillgher order interpolation, Interpolating polynomial by Lagranges Interpolation		
16	Interpolating polynomial by Gregory-Newton forward and backward difference Interpolation and Stirling Interpolation.		
17	Bivariate Interpolation: Lagranges Interpolation and Newtons Interpolation		
18	Numerical differentiation: Finite differences (forward, backward and central), Numerical Partial differentiation		
19	Numerical differentiation and Integration based on Interpolation		
20	Numerical Integration: Trapezoidal rule, Simpsons 1/3rd rule, Simpsons 3/8th rule		
21	Composite integration methods: Trapezoidal rule, Simpsons rule		

<table>
<tr><td>T.Y.B.Sc.</td><td>Semester VI Practical</td></tr>
<tr><td>RJSUMATP602
Practical-II

Topology of Metric Spaces-II , Number Theory and its applications – II, OR Numerical Analysis – II</td><td>Course Outcome 6.2:
1. Problems based on metric spaces
2. To learn continuity in metric spaces through examples
3. To study connetedness in matric spaces
4. To determine solvability of quadratic congruences
5. To generate infinite continued fraction
6. To implement Lagrange's and Newton's interpolation formulae
7. To implement Trapezoidal, Simpson's $1/3^{rd}$, Simpson's $3/8^{th}$ rule
Learning Outcome :
➢ Compactness in metric spaces
➢ Continuity in metric spaces
➢ To know method for getting better approximations for irrational numbers
➢ To learn properties of number theoretic functions
➢ To know how to find approximate value missing data
➢ To be able to find approximate value of definite integrals</td></tr>
</table>

Reference books:

1. Tom M. Apostol, Calculus Vol. 2, second edition, John Wiley, India
2. Jerrold E. Marsden, Anthony J. Tromba, Alan Weinstein, Basic Multivariable Calculus, Indian edition, Springer-Verlag
3. Dennis G. Zill, Warren S. Wright, Calculus Early Transcendentals, fourth edition, Jones and Bartlett Publishers
4. R. R. Goldberg, Methods of Real Analysis, Indian Edition, Oxford and IBH publishing, New Delhi.
5. S.C. Malik, Savita Arora, Mathematical Analysis, third edition, New Age International Publishers, India.
6. Ajit Kumar, S. Kumaresan, A Basic Course in Real Analysis, CRC Press.
7. Charles G. Denlinger, Elements of Real Analysis, student edition, Jones & Bartlett Publishers.
8. M. Thamban Nair, Calculus of One Variable, student edition, Ane Books Pvt. Ltd.
9. Russell A. Gordon, Real Analysis A First Course, Second edition, Addison-Wesley.
10. James Ward Brown, Ruel V. Churchill, Complex variables and applications, seventh edition, McGraw Hill
11. Alan Jeffrey, Complex Analysis and Applications, second edition, CRC Press
12. Reinhold Remmert, Theory of Complex Functions, Springer
13. S. Ponnusamy, Foundations of Complex Analysis, second edition, Narosa Publishing House
14. Richard A. Silverman, Introductory Complex Analysis, Prentice-Hall, Inc.
15. Dennis G. Zill, Patrick D. Shanahan, Complex Analysis A First Course with Applications, third edition, Jones & Bartlett
16. H.S. Kasana, Complex Variables Theory and Applications, second edition, PHI Learning Private Ltd.
17. Jerrold E. Marsden, Michael Hoffman, Basic Complex Analysis, third edition, W.H. Freeman, New York
18. S. Kumaresan, Linear Algebra, A Geometric Approach.
19. Ramachandra Rao and P. Bhimasankaram, Tata McGraw Hill Publishing Company
20. T. Banchoff and J. Wermer, Linear Algebra through Geometry, Springer.
21. L. Smith, Linear Algebra, Springer.
22. M. R. Adhikari and Avishek Adhikari, Introduction to linear Algebra, Asian Books Private Ltd.
23. K Hoffman and Kunze, Linear Algebra, Prentice Hall of India, New Delhi.
24. Inder K Rana, Introduction to Linear Algebra, Ane Books Pvt. Ltd.
25. P. B. Bhattacharya, S. K. Jain, and S. R. Nagpaul, Abstract Algebra, Second edition, Foundation Books, New Delhi.
26. N. S. Gopalakrishnan, University Algebra, Wiley Eastern Limited.
27. I. N. Herstein. Topics in Algebra, Wiley Eastern Limited, Second edition.

28. M. Artin, Algebra, Prentice Hall of India, New Delhi.
29. J. B. Fraleigh, A First course in Abstract Algebra, Third edition, Narosa, New Delhi.
30. J. Gallian, Contemporary Abstract Algebra, Narosa, New Delhi.
31. . S. Kumaresan, Topology of Metric spaces.
32. E. T. Copson. Metric Spaces. Universal Book Stall, New Delhi.
33. Expository articles of MTTS programme.
34. Niven, H. Zuckerman and H. Montogomery, An Introduction to the Theory of Numbers, John Wiley & Sons. Inc.
35. David M. Burton, An Introduction to the Theory of Numbers, Tata McGraw Hill Edition.
36. G. H. Hardy and E.M. Wright. An Introduction to the Theory of Numbers. Low priced edition. The English Language Book Society and Oxford University Press.
37. Neville Robins, Beginning Number Theory, Narosa Publications.
38. S.D. Adhikari, An introduction to Commutative Algebra and Number Theory, Narosa Publishing House.
39. N. Koblitz, A course in Number theory and Cryptography, Springer.
40. M. Artin, Algebra, Prentice Hall.
41. K. Ireland, M. Rosen, A classical introduction to Modern Number Theory, Second edition, Springer Verlag.
42. William Stallings, Cryptology and network security, Pearson Education.
43. T. Koshy, Elementary number theory with applications, 2^{nd} edition, Academic Press.
44. A. Baker, A comprehensive course in number theory, Cambridge.
45. Kendall E. and Atkinson, An Introduction to Numerical Analysis, Wiley.
46. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publications.
47. S. D. Conte and Carl de Boor, Elementary Numerical Analysis, An algorithmic approach, McGraw Hill International Book Company.
48. S. Sastry, Introductory methods of Numerical Analysis, PHI Learning.
49. Hildebrand F.B., Introduction to Numerical Analysis, Dover Publication, NY.
50. Scarborough James B., Numerical Mathematical Analysis, Oxford University Press, New Delhi.
51. Robert Bartle and Donald R. Sherbert, Introduction to Real Analysis, Second Edition, John Wiley and Sons
52. Ajit Kumar, S. Kumaresan, Basic course in Real Analysis, CRC press
53. R.R. Goldberg, Methods of Real Analysis, Oxford and International Book House (IBH) Publishers, New Delhi.

Scheme of Examination

1. There will be theory examination of 100 marks for each of the courses RJSUMAT501, RJSUMAT502, RJSUMAT503, RJSUMAT504(A/B) and practical examination of 100 marks for each course RJSUMATP501 and RJSUMATP502 of semester V and theory examination of 100 marks for each of the courses RJSUMAT601, RJSUMAT602, RJSUMAT603, RJSUMAT604(A/B) and practical examination of 100 marks for each course RJSUMATP601 and RJSUMATP602 of semester VI.
2. Passing in theory and practical shall be separate.
3. Passing percentage is 40 percent.
4. 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 RJSUMAT501, RJSUMAT502, RJSUMAT503, RJSUMAT504(A/B) of semester V and RJSUMAT601, RJSUMAT602, RJSUMAT603, RJSUMAT604(A/B) of semester VI.
    (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 Assessment : There will be two Internal Assessments each of 20 marks for each of the courses RJSUMAT501, RJSUMAT502, RJSUMAT503, RJSUMAT504(A/B) of semester V and RJSUMAT601, RJSUMAT602, RJSUMAT603, RJSUMAT604(A/B) of semester VI.

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 RJSUMAT501, RJSUMAT502, RJSUMAT503, RJSUMAT504(A/B) of semester V and RJSUMAT601, RJSUMAT602, RJSUMAT603, RJSUMAT604(A/B) of semester VI.

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 V & VI Practical examinations of three hours duration and 100 marks shall be conducted for the courses RJSUMATP501, RJSUMATP502 of semester V and RJSUMATP601, RJSUMATP602 of semester VI.
In semester V, the Practical examinations for RJSUMATP501 and RJSUMATP502 will be held together.
In Semester VI, the Practical examinations for RJSUMATP601 and RJSUMATP602 will be held together.
Paper pattern: The question paper shall have two 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. (8x 3 = 24 Marks)

Practical Course	Part A	Part B	Marks out of	duration
RJSUMATP501	Questions from RJSUMAT501	Questions from RJSUMAT502	80	3 hours
RJSUMATP502	Questions from RJSUMAT503	Questions from RJSUMAT504(A/B)	80	3 hours
RJSUMATP601	Questions from RJSUMAT601	Questions from RJSUMAT602	80	3 hours
RJSUMATP602	Questions from RJSUMAT603	Questions from RJSUMAT604(A/B)	80	3 hours

Marks for Journals:
For each course RJSUMAT501, RJSUMAT502, RJSUMAT503, RJSUMAT504, RJSUMAT601, RJSUMAT602, RJSUMAT603, RJSUMAT604:
Journals: 10 marks.

Each Practical of every course of Semester V and VI 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.