Hindi Vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College

of Arts, Science & Commerce

(Autonomous College)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for the F.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.

F.Y.B.Sc Mathematics Syllabus Semester I & II

DISTRIBUTION OF TOPICS AND CREDITS

F.Y.B.Sc. MATHEMATICS SEMESTER I

Course	Nomenclature	Credits	Topics
RJSUMAT101	Calculus-I	02	1. Real numbers 2 Sequences of real numbers 3. Graphs and limits of functions
RJSUMATI02	Algebra-I	02	4. Integers 5. Congruences 6. Relations and functions
RJSUMATP101	Practical I	02	Real numbers, sequences of real numbers, graphs and limits of functions, integers, congruences, relations and functions

F.Y.B.Sc. MATHEMATICS SEMESTER II

Course	Nomenclature	Credits	Topics
RJSUMAT201	Calculus-II	02	1. Continuity and its applications 2. Differentiation 3. Applications of differentiation
RJSUMAT202	Algebra-II	02	4. Polynomials 5. Counting principles and permutations 6. System of linear equations and matrices
RJSUMATP201	Practical II	02	Continuity and its applications, differentiation, applications of differentiation, polynomials, counting principles and permutations, system of linear equations and matrices

SEMESTER I (THEORY)		**L**	**Cr**
Paper-I: Calculus- I	**Paper Code:** RJSUMAT101	45	2
UNIT I		13	
REAL NUMBERS			
1	Algebraic and order properties of real numbers, absolute value of real numbers, intervals and neighborhoods, Hausdorff property, bounded sets, supremum and infimum, completeness property, Archimedean property, density of rational numbers in set of real numbers, nested intervals property.		
UNIT II		20	
SEQUENCES OF REAL NUMBERS			
1	Sequence, Convergent sequences, limit of a sequence, uniqueness of limit, boundedness of a convergent sequence, algebra of limits of sequences, squeeze theorem for sequences, Cauchy sequences, monotone sequences, monotone convergence theorem, subsequences, convergence of some standard sequences like (b^n) (where $\|b\| < 1$), $c^{1/n}$ (for $c > 0$), $n^{1/n}$, $\left(1 + 1/n\right)^n$. Bolzano-Weierstrass theorem for sequences, Cauchy completeness of real numbers.		
UNIT III		12	
GRAPHS AND LIMITS OF FUNCTIONS			
1	Graphs of real valued functions like $\|x\|$, e^x, $\ln x$, $\sin x$, $\cos x$, $\frac{1}{x}$, $x\sin\frac{1}{x}$ etc. with domain as intervals in $\mathbb{R}$.		
2	Limit of a real valued function at a point, sequential definition, $\varepsilon - \delta$ definition and their equivalence, uniqueness of limit, algebra of limits of functions, squeeze theorem for limits, one sided limits, infinite limits and limits at infinity.		

F.Y.BSc	Semester I Theory : Calculus-I
RJSUMAT101 Paper I Calculus- I	Course Outcomes1.1 : 1. Learning of real number system and some of its properties like, order property, Hausdorff property, Archimedean property 2. Understanding of bounded sets in $\mathbb{R}$ and supremum, infimum, LUB axiom and its consequences 3. To learn the concept of sequence of real numbers and its behavior using some results 4. To study subsequences and Cauchy sequence 5. To know graphs of some standard functions Learning outcomes: ➢ Real number system and its algebraic properties, geometric properties ➢ Bounded sets and their infimum and supremum ➢ Sequence of real numbers and its convergence ➢ Graphs of some standard functions and limits

SEMESTER I (THEORY)		**L**	**Cr**
Paper-II: Algebra-I	**Paper Code:** RJSUMAT102	45	2
UNIT I		15	
INTEGERS			
1	Statement of well-ordering property of non-negative integers, Principles of mathematical induction (first and second) as a consequence of well-ordering property.		
2	Divisibility in integers, division algorithm, greatest common divisor (g.c.d.) and least common multiple (l.c.m.) of two integers, basic properties of g.c.d. such as existence and uniqueness of g.c.d. and the g.c.d. of integers a and b can be expressed as $ma + nb$ for some $m, n \in \mathbb{Z}$, Euclidean algorithm and extended Euclidean algorithm.		
3	Primes, Euclid's lemma, Fundamental theorem of arithmetic, infinitude of primes.		
UNIT II		15	
CONGRUENCES			
1	Congruences, definition and elementary properties, Euler's ϕ function, Properties of Euler's ϕ function, Euler's theorem, Fermat's theorem and Wilson's theorem and their applications, linear congruences, linear Diophantine equations.		
UNIT III		15	
RELATION AND FUNCTIONS			
1	Definition of a function, domain, codomain and range of a function, composite functions, examples, Direct image and inverse image of sets under a function, injective, surjective, bijective functions, Composite of injective, surjective, bijective functions when defined. Invertible functions, bijective functions are invertible and conversely. Examples of functions including constant, identity, projection, inclusion.		
2	Binary operation - its properties and examples.		
3	Equivalence relation, Equivalence classes, properties such as two equivalences classes are either identical or disjoint, Definition of partition, every partition gives an equivalence relation and vice versa.		
4	Congruence is an equivalence relation on $\mathbb{Z}$, Residue classes and partition of $\mathbb{Z}$, addition and multiplication modulo n in $\mathbb{Z}_n$.		

F.Y.BSc	Semester I Theory : Algebra-I
RJSUMAT102 Paper II Algebra-I	Course Outcomes1.2 : 1. To learn concepts of integers such as gcd, lcm, primes, fundamental theorem of arithmetic 2. To understand concepts of congruences, Fermat's theorem, Euler's theorem, Wilson's theorem and their role in large computations. 3. To learn basic terminologies of functions such as injective, surjective, bijective, inverse functions, composition of functions. 4. To understand binary operation and its various properties like commutative, associative, identity, inverse. 5. To understand concepts and of relations such as reflexive, symmetric, transitive, equivalence relations. Learning outcomes: ➢ To know properties of prime number. ➢ To understand mathematical induction as a proof technique. ➢ To understand basics of functions.

SEMESTER II (THEORY)			**L**	**Cr**
Paper-I: Calculus-II		**Paper Code:** RJSUMAT201	45	2
UNIT I			15	
CONTINUITY AND ITS APPLICATIONS				
1	Continuity of real valued functions defined on intervals, sequential definition, $\varepsilon - \delta$ definition and their equivalence, algebra of continuous functions, composite of continuous functions, uniform continuity, sign preserving property of continuous function, intermediate value theorem, A continuous function on closed and bounded interval is bounded and attains its bounds; also its image is closed and bounded interval.			
UNIT II			15	
DIFFERENTIATION				
1	Differentiability of functions, its geometrical and physical interpretation, non differentiable functions, necessary condition for differentiability of real valued function, algebra of differentiable functions, Carathéodory's lemma, derivative of inverse functions, chain rule, higher order derivatives, Leibnitz rule, implicit differentiation, Rolle's theorem, mean value theorems, L'Hôpital's rule.			
UNIT III			15	
APPLICATIONS OF DIFFERENTIATION				
1	Increasing and decreasing functions, extreme values, stationary points, first derivative test, second derivative test, higher derivative test, point of inflection, convex and concave functions, Taylor's theorem, linear and quadratic approximations, Newton's and Picard's methods for finding solutions of equations.			

F.Y.BSc	Theory Semester II : Calculus-II
RJSUMAT201 paper I Calculus-II	Course Outcomes2.1 : 1. To know the notion of continuity 2. To learn advance results related to continuity of real functions 3. Finding of derivatives using Leibniz definition and some elementary results 4. To find stationary points, extreme values of functions using second derivative test 5. To study Mean value theorems and their applications 6. Evaluating of indeterminate forms using L'Hopital's rule Learning outcomes: ➢ Properties of continuous functions ➢ Differentiation and its applications

		L	Cr
SEMESTER II (THEORY)			
Paper-II: Algebra-II	**Paper Code: RJSUMAT202**	45	2
UNIT I		15	
POLYNOMIALS			
1	Definition of polynomials over $\mathbb{Q}$, $\mathbb{R}$ or $\mathbb{C}$, Algebra of polynomials, degree of polynomial, basic properties.		
2	Division algorithm in $F[X]$ (without proof), and g.c.d. of two polynomials and its basic properties (without proof), Euclidean algorithm (without proof), applications, Roots of a polynomial, relation between roots and coefficients, multiplicity of a root, Remainder theorem, Factor theorem.		
3	A polynomial of degree n has at most n roots, Complex roots of a polynomial in $\mathbb{R}[X]$ occur in conjugate pairs, Statement of Fundamental Theorem of Algebra, A polynomial of degree in $\mathbb{C}[X]$ has exactly n complex roots counted with multiplicity, Rational root theorem, simple consequences such as $\sqrt{p}$ is a irrational number where p is a prime number, Eisenstein's Criterion for irreducibility of a polynomial with integer coefficient (without proof), roots of unity, sum of all the roots of unity.		
UNIT II		15	
COUNTING PRINCIPLES AND PERMUTATIONS			
1	Finite and infinite sets, countable and uncountable sets examples such as $\mathbb{N}$, $\mathbb{Z}$, $\mathbb{N}\times\mathbb{N}$, $\mathbb{Q}$, (0, 1), $\mathbb{R}$.		
2	Permutation and combination of sets and multisets, Multinomial theorem, Principle of inclusion and exclusion and its applications.		
3	Permutation of objects, S_n, composition of permutations, definition of cycles, transposition, results such as every permutation is a product of disjoint cycles, every cycle is a product of transpositions, even and odd permutations, definition of A_n, signature of a permutation, cardinality of S_n and A_n.		
UNIT III		15	
SYSTEM OF LINEAR EQUATIONS AND MATRICES			
1	Definition of *n-tuples* of real numbers, sum of two *n-tuples* and scalar multiple of *n-tuples*. Parametric equation of lines and planes. System of homogeneous and nonhomogeneous linear equations, the solution of system of m homogeneous linear equations in n		

	unknowns by elimination and their geometrical interpretation for (m, n) = (1; 2); (1; 3); (2; 2); (2; 3); (3; 3).		
2	Elementary row operations, elementary matrices, invertible matrices, elementary matrices are invertible and an invertible matrix is a product of elementary matrices. Row echelon form of matrices, rank of a matrix.		
3	System of linear equations in matrix form, Gaussian elimination method to solve any system of linear equations and to find inverse of a matrix. System of m homogeneous linear equations in n unknowns has a non-trivial solution if m < n.		

F.Y.BSc	Theory Semester II : Algebra-II
RJSUMAT202 Paper II Algebra-II	Course Outcomes2.2 : 1. To understand terminologies of polynomials, finding roots and their relation with coefficients. 2. To know elementary definitions in S_n like transpositions, signature of a permutation, even and odd permutations. 3. To learn cardinalities of sets and basic principles of counting 4. To study multinomial theorem, inclusion-exclusion theorem and their applications 5. System of linear equations in matrix form and methods to solve it. 6. To study concepts of Row echelon and rank of a matrix. Learning outcomes: ➢ Polynomials and their roots. ➢ Elementary calculations in S_n ➢ To know classification sets through their cardinalities ➢ Learn Geometrical interpretation of simple system of equations. ➢ To know basic and advanced techniques of counting

Semester I (PRACTICALS)		L	Cr
Practical-I: Calculus –I & Algebra-I	**Paper Code: RJSUMATP101**		**2**
1	Order properties, absolute value, Hausdorff property		
2	Bounded sets, supremum and infimum, Archimedian property		
3	Convergent sequences, divergent sequences, sandwich theorem		
4	Monotone sequences, Cauchy sequences, Subsequences		
5	Drawing graphs of functions		
6	Limits of functions, sandwich theorem, non existence of limits		
7	Miscellaneous theoretical questions based on three units of Calculus-I		
8	Mathematical induction, Divisibility		
9	GCD, primes and their properties		
10	Congruences		
11	Linear congruences		
12	Functions		
13	Binary operations and Equivalence relations		
14	Miscellaneous theoretical questions based on three units of Algebra-I		

F.Y.BSc	Practicals Semester I
RJSUMATP101 Practical I	Course Outcomes: 1. To understand the method of expressing gcd as a linear combination 2. To simplify higher powers implementing the properties of congruences 3. To study real number system and its properties through examples 4. To study sequences and of real numbers Learning outcomes: ➢ To know methods of simplifying higher powers in integers through gcd, prime and congrunces ➢ Real numbers and their algebraic and geometric properties ➢ Sequence and of real numbers ➢ To draw graph of functions

		L	Cr
Semester II (PRACTICALS)			
Practical-II: Calculus-II & Algebra-II	**Paper Code: RJSUMATP201**		**2**
1	Continuous functions ϵ-δ definition, sequential continuity		
2	Applications of continuous functions		
3	Derivatives, non differentiable functions, Leibnitz theorem		
4	Mean value theorems, L'Hôpital's rule		
5	Monotone functions, extreme values, convex and concave functions		
6	Taylor's theorem, approximations, solutions of equations by Newton's and Picard's methods		
7	Miscellaneous theoretical questions based on three units of Calculus-II		
8	GCD of two polynomial, relation between roots and coefficients of polynomials, factorization		
9	Rational root theorem, Eisenstein's Criterion		
10	Problems based on counting principles, Inclusion-Exclusion principle		
11	Permutations (S_n).		
12	Solving homogeneous system of m equations in n unknowns and their geometrical interpretation for (m; n) = (1; 2); (1; 3); (2; 2); (2; 2); (3; 3), Row echelon form		
13	Solving any m by n linear system of equations, elementary matrices and invertible matrices		
14	Miscellaneous Theoretical Questions based on three units of Algebra-II		

F.Y.B.Sc	Semester II
RJSUMATP201 Practical - I	Course Outcomes: 1. Continuity of function using $\varepsilon - \delta$ definition and sequence 2. Maxima and minima of functions 3. Mean value theorems 4. Solving system of linear equations 5. To study relation between roots of polynomial and coefficients Learning outcomes: ➢ Continuous functions and their properties ➢ Higher order derivatives ➢ Applications of derivatives ➢ Learn Gaussian elimination method to solve the system. ➢ To learn counting principles and their applications

Reference books:

1. Robert G. Bartle, Donald R. Sherbert, Introduction to Real Analysis, third edition, John Wiley & Sons, Inc.
2. Sudhir R. Ghorpade, Balmohan V. Limaye, A Course in Calculus and Real Analysis, International edition, Springer.
3. Charles G. Denlinger, Elements of Real Analysis, student edition, Jones & Bartlett.
4. S. C. Malik, Savita Arora, Mathematical Analysis, third edition, New Age International Publishers, India.
5. William Trench, Introduction to Real Analysis, Free hyperlinked edition.
6. Kenneth A. Ross, Elementary Analysis: The Theory of Calculus, International edition, Springer.
7. Ajit Kumar, S. Kumaresan, A Basic Course in Real Analysis, CRC Press.
8. M. Thamban Nair, Calculus of One Variable, student edition, Ane Books Pvt. Ltd.
9. David M. Burton, Elementary Number Theory, Seventh Edition, McGraw Hill Education (India) Private Ltd.
10. Norman Biggs, Discrete Mathematics, Oxford University Press.
11. Niven and S. Zuckerman, Introduction to the theory of numbers, Third Edition, Wiley Eastern, New Delhi
12. G. Birkhoff and S. Maclane, A Survey of Modern Algebra, Third Edition, MacMillan
13. Kenneth Rosen, Discrete Mathematics and its applications, Mc-Graw Hill International Edition, Mathematics Series.
14. L. N. Childs, Concrete introduction to higher algebra, Third Edition, Springer
15. Richard Brualdi, Introductory Combinatorics, John Wiley and sons
16. V. Krishnamurthy, Combinatorics-Theory and Applications, Affiliated East West Press.
17. S. S. Sane, Combinatorial Techniques, Hindustan Book Agency.
18. K. Rosen, Discrete Mathematics and its Applications, Tata McGraw Hills.
19. Schaum's outline series, Discrete mathematics.
20. L. N. Childs, Concrete introduction to higher algebra, Third Edition, Springer.

Scheme of Examination

Internal Assessments: There will be two Internal Assessments each of 20 marks for each of the courses RJSUMAT101, RJSUMAT102 of Semester I and RJSUMAT201, RJSUMAT202 of semester II.

Internal Assessment I and II pattern: There will be two internal examinations for each courses RJSUMAT101, RJSUMAT102 of semester I and RJSUMAT201, RJSUMAT202 of semester II. The internal assessment will be based on class tests / projects / assignments / book review / seminars.

The pattern for internal class test will be as follows

(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 RJSUMAT101, RJSUMAT102 of Semester I and RJSUMAT201, RJSUMAT202 of semester II

1. Duration: The examinations shall be of 2 Hours duration.
2. Theory Question Paper Pattern:

a) For paper 1 semester I, there shall be three questions Q1, Q2 , Q3 of 18, 24, 18 marks respectively based on the units I, II, III respectively.

Q1 will be as follows:
(i) Attempt any one out of two questions (each of 8 marks).
(ii) Attempt any two out of four questions (each of 5 marks).

Q2 will be as follows:
(i) Attempt any one out of two questions (each of 10 marks).
(ii) Attempt any two out of four questions (each of 7 marks)

Q3 will be as follows:
(i) Attempt any one out of two questions (each of 8 marks).
(ii) Attempt any two out of four questions (each of 5 marks)

b) For paper 1 semester II and paper 2 semesters I and II, there shall be three questions Q1, Q2 , Q3 each of 20 marks and each based on the units I, II, III respectively.

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)

c) All the questions shall be compulsory. The questions Q1, Q2, Q3 shall have internal choices within the questions.

Semester End Practical Examinations:
At the end of the Semesters I & II Practical examinations of three hours duration and100 marks shall be conducted for the courses RJSUMATP101, RJSUMATP201.
In semester I, the Practical examinations for RJSUMAT101 and RJSUMAT102 will be held together.
In Semester II, the Practical examinations for RJSUMAT201 and RJSUMAT202 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	Duration
RJSUMATP101	Questions from RJSUMAT101	Questions from RJSUMAT102	80	3 hours
RJSUMATP201	Questions from RJSUMAT201	Questions from RJSUMAT202	80	3 hours

Marks for Journals:
For each course RJSUMAT101, RJSUMAT102, RJSUMAT201 and RJSUMAT202.
Journals: 10 marks.

Each Practical of every course of Semester I and II 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.