Royal College of Arts Science andCommerce (Autonomous)

Affiliated to University of Mumbai

Program: F. Y. B. Sc

Course: Mathematics

Syllabus for Semester: I and II

Syllabus for Undergraduate Programme as per National Education Policy (NEP-2020) with effect from the academic year 2024-2025

NEP Credit Structure for Science

Level	Sem	Major		Minor	OE	VSC	SEC	AEC	IKS	VEC	OJT/FP /RP/CC /CEP	Cumulative Credits	
		DSC	DSE										
4.5	I	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2	2		2	2	2		22	**UG Certificate Cumulative Credit:44**
	II	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2		2	2		2	2	22	
Exit Option: Award of UG Certificate in Major with 40 -44 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5	III	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	**UG Diploma Cumulative Credit:88**
	IV	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	
Exit Option: Award of UG Diploma in Major and Minor with 80-88 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5.5	V	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22+	**UG Degree Cumulative Credit:132**
	VI	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22	
	Total	**48**	**8**	**20**	**12**	**10**	**6**	**8**	**2**	**4**	**14**	**132**	

List of All Courses offered from Semesters I – VI in _____

Level	Sem	Major subject Course titles	Minor subject Course titles	Elective Course titles	OE Course titles	VSC Course title/s	SEC Course title/s
4.5 100-199	I	Calculus – I Linear Algebra - I	-	-	Data analysis and visualization		-
	II	Calculus – II Linear Algebra - II	-	-	Data analysis and forecasting	-	
5 200-299	III	-	Calculus – III	-	Mathematics for competitive examination - I	-	-
	IV	-	Calculus - IV	-	Mathematics for competitive examination - II	-	-
5.5 300-399	V	-	-	-	-	-	-
	VI		-	-	-	-	-

Course/ Paper Title	**CALCULUS - I**
Course offered as	**Major**
Course Code	**RUSMAMJ101**
Semester	**I**
No. of Credits	**2**
No. of lecture Hours/week	**2 L**

Sr No.	**Course Learning Objectives**
CLO1	To familiarize them with theorems and basic properties of the field of real numbers.
CLO2	To introduce theorems and properties of convergent Cauchy and divergent sequences and their applications to solve complex real-life problems.
CLO3	To give an understanding of the different tests for the convergence of series of Real numbers
CLO4	To give knowledge of fundamental principles and methods to identify continuous functions.

Course Outcome:

	On completing the course, the student will be able to:
CO1	Define and interpret the fundamental properties of real numbers as an ordered set.
CO2	Recognize bounded, convergent, divergent, Cauchy, and monotonic sequences.
CO3	apply appropriate tests for convergence and absolute convergence of an infinite series of real numbers.
CO4	calculate the limit, and investigate the continuity of a function at a point using algebraic manipulation.

Detailed Syllabus:

Module	Title with content	No. of lectures
I	Prerequisite: Domain and range of a function of one variable, injective function, surjective function, bijective function, composite of two functions, inverse of a bijective function. **Real analysis:** Real numbers: Real numbers and their properties, Absolute value and its properties, bounded subsets of $\mathbb{R}$ supremum and infimum of a set, Archimedean property of $\mathbb{R}$, Intervals and neighborhoods. Nested interval theorem. Density of rational.	10 Hours
II	**Sequence and Series of real numbers:** Sequences of real numbers: Definition of Real sequences, Bounded sequences. Monotonic sequences, convergent, divergent, and oscillatory sequences. Limit of a sequence. Algebra of convergent sequences, Cauchy sequences. Definition of convergent, divergent and oscillatory series. Series of non-negative terms, Cauchy's general principle of convergence. Geometric series, P-series (Harmonic series). Comparison tests for positive term series. D'Alembert's ratio test, Raabe's test. Cauchy's Root test and Cauchy's integral test. Alternating series. Leibnitz's theorem. Absolute convergence and conditional convergence of a series.	10 Hours
III	**Limits and Continuity of functions:** $\epsilon - \delta$ definition of a limit of a function, uniqueness of limit. Algebra of limits, Sandwich theorem for functions, Definition and properties of continuous functions, sequential continuity, types of discontinuities. Continuous functions: Continuity of a real valued function on a set in terms of limits, examples, Continuity of a real valued function at end points of domain, Algebra of continuous functions, Sequential continuity, Intermediate value theorem, Discontinuous functions, examples of removable and essential discontinuity.	10 Hours

References:

1. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
2. Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and Real Analysis, Springer International Ltd, 2000.
3. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964.
4. T. M. Apostol, Calculus Volume I, Wiley & Sons (Asia) Pte, Ltd.
5. James Stewart, Calculus, Third Edition, Brooks/ Cole Publishing Company, 1994.

Course/ Paper Title	**LINEAR ALGEBRA I**
Course offered as	**Major**
Course Code	**RUSMAMJ102**
Semester	**I**
No. of Credits	**2**
No. of lecture Hours/week	**2 L**

Sr No.	Course Learning Objectives:
CLO1	To introduce system of linear equations and matrices.
CLO2	To introduce concept of vector spaces

Course Outcome:

	On completing the course, the student will be able to:
CO1	Solve system of linear equations using matrices.
CO2	Define and interpret system of linear equations and their solutions geometrically.
CO3	Define vector spaces, subspaces, basis and dimension of vector spaces.

Detailed Syllabus:

Module	Title with content	No. of lectures
I	**Matrices:** Matrices with real entries- Types of matrices, Algebraic operations on matrices, transpose of a matrix, invertible matrices, Adjoint, determinant, inverse of a matrix, Row operations, row equivalent matrices, row echelon form, rank of a matrix, LU decomposition of matrices.	10 Hours
II	**System of linear equations:** System of linear equations. Geometric interpretation, homogeneous and non-homogeneous linear equations. Matrix form of system of linear equations. Gauss elimination method to solve system of equations, Cramer's rule, LU decomposition method.	10 Hours
III	**Vector space:** Definition and examples of vector space, subspaces, linearly independent and linearly dependent vectors, linear span, basis and dimension of vector space	10 Hours

References:

1. Gilbert Strang, Linear Algebra and its Applications, fourth edition, Cengage India Private Limited, 2005
2. Serge Lang, Introduction to linear algebra, second edition, Springer, 1986
3. S. Kumaresan, Linear algebra, a geometric approach, first edition, Prenticeh all of India, 2009
4. S Axler, Linear algebra done right, fourth edition, Springer Cham, 2023

Course/ Paper Title	**PRACTICAL I**
Course offered as	**Major**
Course Code	**RUSMAMJP1**
Semester	**I**
No. of Credits	**2**
No. of lecture Hours/week	**4 (2 P)**

Sr No.	Course Learning Objectives:
CLO1	To acquire the knowledge of application of sequence and series.
CLO2	To apply knowledge of continuous functions.
CLO3	To acquire knowledge of applications of system of equations.
CLO4	To apply concept of vector spaces

Course Outcome:

	On completing the course, the student will be able to:
CO1	Apply appropriate tests for convergence and absolute convergence of an infinite series of real numbers.
CO2	calculate the limit and investigate the continuity of a function at a point using algebraic manipulation.
CO3	Interpret system of linear equations and solve system of linear equations using matrices.
CO4	Students will be able to define vector spaces, subspaces, basis and dimension of vector spaces.

Regular experiments:

Sr No.	Practical topics for CALCULUS I
1	Algebraic and Order Properties of Real Numbers and Inequalities
2	Hausdorff Property and LUB Axiom of R, Archimedian Property
3	Convergence and divergence of sequences, bounded sequences, Sandwich Theorem. Monotonic sequences, Cauchy sequences. Convergent / divergent series and algebra of convergent series. Tests for convergence of series.
4	Limits and Continuity, algebra of limits and continuity and applications of theorems on continuous functions.

Regular experiments:

Sr No.	Practical topics for LINEAR ALGEBRA I
1	Problems on finding inverse of a matrix if it exists.
2	Problems on finding rank of a matrix
3	Problems on solving system of equations using matrices- Gauss elimination and Cramer's rule.
4	Problems on Vector spaces and subspaces.
5	Problems on linearly dependent and linearly independent vectors, linear span.
6	Problems on basis and dimension.

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Theory Examination Pattern for

(Major/ Minor)

The performance of the learners shall be evaluated in two parts.

- Internal Continuous Assessment of 20 marks.
- Semester End Examination of 30 marks.
- A separate head of passing is required for internal and semester-end examinations

I	**Internal Assessment**	20 Marks
a	One class test (Short answers/Objectives/ Multiple Choice)	10 marks
b	Assignment/ Project/ Presentation/Book or research paper Review/	10 marks
II	**Semester End Examination**	30 Marks
	Duration	1 Hour

Question Paper Pattern (Class test):

Q 1)	Fill in the blanks/True or False	4 Marks
Q 2)	Attempt any 2/3 descriptive questions	6 Marks

Question Paper Pattern (Sem end Examination):

Q 1)	Module 1,2,3	Attempt any 6/9 questions (MCQ)	6 Marks
Q 2) a)	Module 1	Attempt any 1/2 questions	8 Marks
Q 2) b)	Module 1	Attempt any 1/2 questions	8 Marks
Q 3) a)	Module 2	Attempt any 1/2 questions	8 Marks
Q 3) b)	Module 2	Attempt any 1/2 questions	8 Marks
Q 4) a)	Module 3	Attempt any 1/2 questions	8 Marks
Q 4) b)	Module 3	Attempt any 1/2 questions	8 Marks

Practical exam (CALCULUS I AND LINEAR ALGEBRA I)

External Assessment for Practical	**50 Marks**
Part A (CALCULUS I)	20 Marks
Part B (LINEAR ALGEBRA I)	20 Marks
Viva	05 Marks
Journal	05 Marks

Course/ Paper Title	**CALCULUS - II**
Course offered as	**Major**
Course Code	**RUSMAMJ201**
Semester	**II**
No. of Credits	**2**
No. of lecture hours/week	**2L**

Sr No.	Course Learning Objectives:
CLO1	To acquaint them with the concept of differentiable functions
CLO2	To teach them to use differentiability to find extrema of functions
CLO3	To introduce the definition of the definite integral as the limit of a Riemann sum.

Course Outcome:

	On completing the course, the student will be able to:
CO1	identify differentiable functions.
CO2	determine maxima and minima in optimization problems using their derivatives.
CO3	determine whether a real valued function is Riemann integrable or not.

Detailed Syllabus:

Module	Title with content	No. of lectures
I	**Differentiability of functions of one variable:** Definition of differentiation at a point of an open interval, examples of differentiable and non-differentiable functions, differentiable functions are continuous but not conversely, chain rule, Higher order derivatives, Leibnitz rule, Derivative of inverse functions.	10 Hours
II	**Application of differentiation:** Rolle's theorem, Lagrange's Mean Value theorem, Cauchy's Mean value theorem, Taylor's theorem with Lagrange's multiplier, Maclaurin's theorem, L'Hospital rule. Definition of local maximum and local minimum, necessary condition, stationary points, points of inflection, second derivative test for Maxima and Minima.	10 Hours
III	**Introduction to integral calculus:** Approximation of area, Upper/Lower Riemann sums and properties, Upper/Lower integrals, Definition of Riemann integral on a closed and bounded interval, Criterion of Riemann integrability	10 Hours

(Two units for a two-credit course and four units for a four credit course.
1 credit = 1 lecture hour/week, 1 credit = 2 practical hours/week)

References:

1. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
2. Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and Real Analysis, Springer International Ltd, 2000.
3. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964.
4. T. M. Apostol, Calculus Volume I, Wiley & Sons (Asia) Pte, Ltd.
5. James Stewart, Calculus, Third Edition, Brooks/ cole Publishing Company, 1994.

Course/ Paper Title	**LINEAR ALGEBRA II**
Course offered as	**Major**
Course Code	**RUSMAMJ202**
Semester	**II**
No. of Credits	**2**
No. of lecture Hours/week	**2L**

Sr No.	Course Objectives:
1	To introduce linear transformation, isomorphism.
2	To introduce concept of inner product on vector spaces.

Course Outcome

	On completing the course, the student will be able to:
CO1	Identify linear transformations and matrix associated
CO2	Define kernel and image of a linear transformation, verify Rank-Nullity theorem
CO3	Define inner product spaces, Projection of a vector
CO4	Solve orthogonal and orthonormal vectors

Detailed Syllabus

Module	Title with content	No. of lectures
I	**Linear transformations and associated matrices:** Definition and examples of linear transformation, isomorphism, Kernel and image of linear transformation, rank-nullity theorem, Representation of linear transformation by matrices.	10 Hours
II	**Inner Product Spaces:** Definition and example of inner product. Norm of a vector, distance between vectors, angle between vectors, projection. Cauchy Schwarz inequality, triangle inequality, parallelogram law, Orthogonal and orthonormal vectors. Gram- Schmidt orthogonalization Process.	10 Hours
III	**Eigenvalues and eigenvectors:** Characteristic polynomial of a matrix, Cayley-Hamilton theorem and applications, Definition and examples of eigen value, eigen vector and eigen space.	10 Hours

References:

1. Gilbert Strang, Linear Algebra and its Applications, fourth edition, Cengage India Private Limited, 2005
2. Serge Lang, Introduction to linear algebra, second edition, Springer, 1986
2. S. Kumaresan, Linear algebra, a geometric approach, first edition, Prenticeh all of India, 2009
3. S Axler, Linear algebra done right, fourth edition, Springer Cham, 2023

Course/ Paper Title	**PRACTICAL II**
Course offered as	**Major**
Course Code	**RUSMAMJP2**
Semester	**II**
No. of Credits	**2**
No. of lecture Hours/week	**2 P**

Sr No.	Course Learning Objectives:
CLO1	To teach them to use differentiability to find extrema of functions
CLO2	To introduce the definition of the definite integral as the limit of a Riemann sum
CLO3	To acquaint students with Linear transformation and determination of associated matrix.
CLO4	To introduce methods to calculate Eigen values, eigen vectors, diagonalizable matrix and their properties.

Course Outcome

	On completing the course, the student will be able to:
CO1	determine maxima and minima in optimization problems
CO2	determine whether a real valued function is Riemann integrable or not.
CO3	Apply the knowledge of Linear transformation and associated matrix, Isomorphism, to solve problems.
CO4	Solve problems on Eigen values, eigen vectors, diagonalizable matrix and their properties.

Regular experiments:

Sr No.	Practical topics for CALCULUS II
1	Problems on properties of Differentiable Functions, differentiability of Inverse functions, Composite functions, Implicit functions.
2	Problems on Higher Order Derivatives, Leibniz Theorem, Mean value theorems and applications, L'Hospital's Rule
3	Problems on Increasing and Decreasing functions. Extreme values, Taylor's Theorem.
4	Problems on calculation of upper sum, lower sum and Riemann integral and properties of Riemann integral.

Regular experiments:

Sr No.	Practical topics for LINEAR ALGEBRA II
1	Problems on linear transformation
2	Problems on finding kernel and image of a linear transformation, Verifying rank-nullity theorem
3	Problems on isomorphism.
4	Problems on matrix associated with a linear transformation.
5	Problems on inner product, norm, distance, angle and projection.
6	Problems on Gram- Schmidt orthogonalization process.
7	Problems on Characteristic polynomial, Cayley-Hamilton theorem
8	Problems on eigen value, eigen vector and eigen space

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Theory Examination Pattern for

(Major/ Minor)

The performance of the learners shall be evaluated in two parts.

- Internal Continuous Assessment of 20 marks.
- Semester End Examination of 30 marks.
- A separate head of passing is required for internal and semester-end examinations

I	**Internal Assessment**	Marks
a	One class test (Short answers/Objectives/ Multiple Choice)	10 marks
b	Assignment/ Project/ Presentation/Book or research paper Review/	10 marks
	Total	20 marks
II	Semester End Examination	30 Marks
	Duration	1 Hour

Question Paper Pattern (Class test):

Q 1)	Fill in the blanks/True or False	4 Marks
Q 2)	Attempt any 2/3 descriptive questions	6 Marks

Question Paper Pattern (Sem end Examination):

Q 1)	Module 1,2,3	Attempt any 6/9 questions (MCQ)	6 Marks
Q 2) a)	Module 1	Attempt any 1/2 questions	4 Marks
Q 2) b)	Module 1	Attempt any 1/2 questions	4 Marks
Q 3) a)	Module 2	Attempt any 1/2 questions	4 Marks
Q 3) b)	Module 2	Attempt any 1/2 questions	4 Marks
Q 4) a)	Module 3	Attempt any 1/2 questions	4 Marks
Q 4) b)	Module 3	Attempt any 1/2 questions	4 Marks
Total			30 Marks

Practical exam (CALCULUS II AND LINEAR ALGEBRA II)

External Assessment for Practical	**50 Marks**
Part A (CALCULUS II)	20 Marks
Part B (LINEAR ALGEBRA II)	20 Marks
Viva + Active participation in practical	05 Marks
Journal	05 Marks

Board of studies in Mathematics

	Category	Name and Designation	Affiliation
1	Chairperson (Head of Department)	Mrs Komal Pravin Wategaonkar, Assistant Professor.	University of Mumbai
2	Full time teacher of the Department	Mrs Rugma Pramod Nair, Assistant Professor.	University of Mumbai
3	Two subject experts from outside the Parent University nominated by the Academic Council.	Dr Ananthnarayan Hariharan, Associate Professor.	I.I.T., Bombay
		Dr. Amiya Bhowmick, Assistant Professor.	ICT Mumbai
4	One expert nominated by the Vice-Chancellor from a panel of six recommended by the College Principal.	Dr. Rajesh Raut Assistant Professor, R. D. National college.	University of Mumbai
5	One expert nominated by the college Principal	Mr. Subhash Krishnan Associate Professor, Vice Principal, K J Somaiya college of Science and Commerce.	University of Mumbai
6	One representative from industry/corporate sector/allied area relating to placement.	Mr. Arbaz Sayed Data Scientist	Data Scientist Wipro, Hyderabad, Telangana
7	One postgraduate meritorious alumnus nominated by the Principal.	Ms. Harshita Rathore, Team Lead, Inventory Management	Supply Chain Fulfillment Manager, Austin, Texas, USA

Board of studies in Mathematics

	Category	Name and Designation	Affiliation	Signature
1	Chairperson (Head of Department)	Mrs Komal Pravin Wategaonkar Assistant Professor	University of Mumbai	Wategaonkar 22/6/24
2	Full time teachers of the Department	Mrs Rugma Pramod Nair Assistant Professor	University of Mumbai	22/6/24
3	Two subject experts from outside the Parent University nominated by the Academic Council.	Dr Ananthnarayan Hariharan Associate Professor	I.I.T., Bombay	FEEDBACK SENT ON OFFICIAL EMAIL
		Dr. Amiya Bowmick Assistant Professor	ICT Mumbai	online
4	One expert nominated by the Vice-Chancellor	Dr. Rajesh Raut Assistant Professor RD National College	University of Mumbai	R.B.Raut 22/06/2024
	One expert nominated by the College Principal.	Mr. Subhash Krishnan Associate Professor, Vice Principal, KJ Somaiya college of Science and Commerce	University of Mumbai	22/6/24
5	One representative from industry/corporate sector/allied area relating to placement.	Mr. Arbaz Sayed Data Scientist	Reliance Corporate Park, Ghansoli, Navi Mumbai	22/6/24
6	One postgraduate meritorious alumnus nominated by the Principal.	Ms Harshita Rathore Team Lead, Inventory Management,	Cisco, Atlanta, USA	online

ROYAL COLLEGE OF ARTS SCI. & COM. DIST. THANE

Principal
ROYAL COLLEGE OF ARTS
SCIENCE & COMMERCE
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