AC: 02.06.2025 ITEM NO: 23.2

Deccan Education Society's

Kirti M. Doongursee College of Arts, Science and Commerce (AUTONOMOUS)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for
Program: Bachelor of Science
Course: S.Y.B.SC.
Subject: Mathematics

Choice Based Credit System (CBCS)
with effect from
Academic Year 2024-2025

PROGRAM OUTCOMES

PO	Description
A student completing Bachelor's Degree in **Science** Program will be able to	
PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate Programme. Execute strong theoretical and practical understanding generated from the specific graduate Programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioral skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.
PO4	**Research-related skills and Scientific temper:** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence:** Performing dependently and collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.

Deccan Education Society's

Kirti M. Doongursee College (autonomous)

Proposed Curriculum as per NEP 2020 Year of implementation- 2024-25

Name of the Department: Mathematics

Semester	Course Code	Course Title	Vertical	Credit
III	24MATMJ311	Calculus -III	Major	2
	24MATMJ312	Linear Algebra -I	Major	2
	24MATMJP31	Practical: Calculus –III & Linear Algebra -I	Major Practical	4
	24MATMR321	Ordinary Differential Equations	Minor	2
	24MATMRP31	Practical : Ordinary Differential Equations	Minor Practical	2
	24MATVC341	Basics of PYTHON	VSC Practical	2
IV	24MATMJ411	Calculus IV	Major	2
	24MATMJ412	Linear Algebra II	Major	2
	24MATMJP41	Practical :Calculus IV & Linear Algebra II	Major Practical	4
	24MATMR421	Numerical methods	Minor	2
	24MATMRP41	Practical: Numerical methods	Minor Practical	2
	24MATSE451	Quantitative Aptitude and Logical reasoning -III	SEC Practical	2

SEMESTER-III

Course Code	MAJOR I	Credits	Lectures/Week
24MATMJ311	PAPER –I CALCULUS III	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Define absolute and conditional convergence of series, critical point, point of inflection, and real number series.

CO2:Describe the concept of maxima and minima, the L-Hospital rule, mean value theorems for differentiability, and how to categorize various test kinds in order to talk about series convergence.

CO3:Apply several tests to check series convergence as well as the concept of differentiability for convexity, concavity, Taylor's polynomial, etc.

CO4:Analyze several tests for series and the notion of differentiability to provide relevant examples to bolster the theory.

Unit	Topics	No of Lectures
I	**Applications of differentiability** Pre-requisite : differentiability. i) Rolle's Theorem, Lagrange's and Cauchy's Mean Value Theorems, applications and examples, Monotone increasing and decreasing functions, examples. ii) L-Hospital rule (without proof), examples of indeterminate forms, Taylor's theorem with Lagrange's form of remainder with proof, Taylor polynomial and applications. iii) Definition of critical point, local maximum/minimum, necessary condition, stationary points, second derivative test, examples, concave/convex functions, point of inflection. Sketching of graphs of functions using properties.	15
II	**Infinite Series** 1. Infinite series in $\mathbb{R}$. Definition of convergence and divergence series. Basic examples including geometric series. Elementary results such as if $\sum_{n=1}^{\infty} a_n$ is convergent, then $a_n \to 0$ as $n \to \infty$ but converse is not true. Cauchy Criterion. Algebra of convergent series.	15

	2. Tests for convergence: Comparison Test, Limit Comparison Test, Ratio Test (without proof), Root Test (without proof), Abel Test (without proof) and Dirichlet Test (without proof). Examples. The decimal expansion of real numbers. Convergence of $\sum_{n=1}^{\infty} \frac{1}{n^p}$ (p > 1). Divergence of harmonic series $\sum_{n=1}^{\infty} \frac{1}{n}$. 3. Alternating series. Leibnitz's Test. Examples. Absolute convergence, absolute convergence implies convergence but not conversely. Conditional Convergence.	

References:

1. Sudhir Ghorpade, Balmohan Limaye; A Course in Calculus and Real Analysis (second edition); Springer.
2. R.R. Goldberg; Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi, 1970.
3. Calculus and Analytic Geometry (Ninth Edition); Thomas and Finney; Addison-Wesley, Reading Mass., 1998.
4. T. Apostol; Calculus Vol. 2; John Wiley.

Additional References:

1. Ajit Kumar, S.Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014
2. D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.
3. K. Stewart; Calculus, Booke/Cole Publishing Co, 1994.
4. J. E. Marsden, A.J. Tromba and A. Weinstein; Basic Multivariable Calculus; Springer.
5. R.G. Bartle and D. R. Sherbert; Introduction to Real Analysis Second Ed. ; John Wiley, New Yorm, 1992.
6. M. H. Protter; Basic Elements of Real Analysis; Springer-Verlag, New York, 1998.

Course Code	MAJOR I	Credits	Lectures/Week
24MATMJ312	PAPER –II LINEAR ALGEBRA I	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Define system of homogeneous , nonhomogeneous linear equations, elementary row and column transformations, determinant of matrix and Cramer's rule.

CO2: Explain Matrix representations of homogeneous , nonhomogeneous linear equations, Gaussian elimination, determinants and linear equations.

CO3: Apply row and column transformations ,row echelon form etc. to solve system of linear equations, Determinants and linear equations to find inverse ,rank and system of equations .

CO4: Examine system of equations, matrices, linear equations to solve related problems.

Unit	Topics	No of Lectures
I	**System of Equations, Matrices** 1.Systems of homogeneous and non-homogeneous linear equations, Simple examples of finding solutions of such systems. Geometric and algebraic understanding of the solutions. Matrices (with real entries), Matrix representation of system of homogeneous and nonhomogeneous linear equations. Algebra of solutions of systems of homogeneous linear equations. A system of homogeneous linear equations with number of unknowns more than the number of equations has infinitely many solutions. 2.Elementary row and column operations. Row equivalent matrices. Row reduction (of a matrix to its row echelon form). Gaussian elimination. Applications to solving systems of linear equations. Examples. 3. Relation between the solutions of a system of non-homogeneous linear equations and the associated system of homogeneous linear equations. Necessary and sufficient condition for a system of non-homogeneous linear equations to have a solution [viz., the rank of the coefficient matrix equals the rank of the augmented matrix [A|B]. Equivalence of statements (in which A denotes an $n \times n$ matrix) such as the following. (i) The system $Ax = b$ of non-homogeneous linear equations has a unique solution. (ii) The system $Ax = 0$ of homogeneous linear equations has no nontrivial solution. (iii) A is invertible.(iv) $\det A \neq 0$. (v) rank(A) = n	15

	4. Elementary matrices. Relation of elementary row operations with elementary matrices. Invertibility of elementary matrices. Consequences such as (i) a square matrix is invertible if and only if its row echelon form is invertible. (ii) invertible matrices are products of elementary matrices. Examples of the computation of the inverse of a matrix using Gauss elimination method.	
II	**Matrices ,Determinants.** 1. Inductive definition of the determinant of a n × n matrix (e. g. in terms of expansion along the first row). Example of a lower triangular matrix. Laplace expansions along an arbitrary row or column. Determinant expansions using permutations $\left(det(A) = \sum_{\sigma \in S_n} sign(\sigma) \prod_{i=1}^{n} a_{\sigma(i),i}\right)$. 2. Basic properties of determinants (Statements only); (i) det A = det A^T . (ii) Multilinearity and alternating property for columns and rows. (iii) A square matrix A is invertible if and only if det A $\neq$ 0. (iv) Minors and cofactors. Formula for A^{-1} when det A $\neq$ 0. (v) det(AB) = det A det B. 3. Row space and the column space of a matrix as examples of vector space. Notion of row rank and the column rank. Equivalence of the row rank and the column rank. Invariance of rank upon elementary row or column operations. Examples of computing the rank using row reduction. 4. Cramers Rule. LU Decomposition. If a square matrix A is a matrix that can be reduced to row echelon form U by Gauss elimination without row interchanges, then A can be factored as A = LU where L is a lower triangular matrix.	15

References:

1. Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student Edition).
2. Serge Lang, Introduction to Linear Algebra, Springer.
3. S Kumaresan, Linear Algebra - A Geometric Approach, PHI Learning

Additional References:

1. Sheldon Axler, Linear Algebra done right, Springer.
2. Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers.
3. David W. Lewis, Matrix theory.

Course Code	PRACTICAL MAJOR I & II	Credits	Lectures/ Week
24MATMJP31	PAPER I & PAPER II (CALCULUS III & LINEAR ALGEBRA I)	4	8

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Describe various properties of Differentiability, convergence, Maxima and minima series, systems of linear equations, echelon form, rank of a matrix.

CO2:Discuss problems based on extrema, mean value theorems, differentiability and Series, systems of linear equations, Echelon form. Minors and cofactors, cramers rule.

CO3:solve the problems based on the syllabus.

CO4:Relate mathematics and its applications in pure and applied sciences.

GROUP A: CALCULUS III

Sr. no.	Practical Details	No of Lectures/ Hours
1	Examples based on Mean Value theorems.	60
2	Examples of Monotone increasing and decreasing functions.	
3	Examples based on indeterminate forms(L-Hospital Rule).	
4	Examples based on Taylor's series and Taylor's polynomial.	
5	Examples based on extreme values.	
6	Examples based on sketching the graphs of functions using concavity.	
7	Examples of convergent / divergent series using definition.	
8	Examples based on geometric series and algebra of convergent series.	
9	Examples on comparison test and limit comparison test.	
10	Examples on ratio test and root test.	
11	Examples on Abel's test and Dirichlet's test.	
12	Examples based on Leibnitz test.	
13	Examples on conditional and absolute convergence.	
14	Miscellaneous Theory Questions based on full paper	

GROUP B : LINEAR ALGEBRA I

1	Problems on systems of homogeneous linear equations.	
2	Problems on systems of non-homogeneous linear equations.	

3	Problems on homogeneous linear equations with number of unknowns more than the number of equations. Problems on non-homogeneous linear equations with number of unknowns more than the number of equations.	60
4	Elementary row/column operations and Elementary matrices.	
5	Echelon form of a matrix.	
6	Problems on Gauss elimination method.	
7	Miscellaneous Theory Questions based on Unit I	
8	Problems based on properties of Determinant and determinant some standard matrices.	
9	Minors and Cofactors of a matrix	
10	Problems based on row space, column space and Rank of a matrix.	
11	Solution to a system of linear equations.	
12	Problems on Cramer's Rule.	
13	Problems on LU decomposition.	
14	Miscellaneous Theory Questions based unit II	

References:

1. Sudhir Ghorpade, Balmohan Limaye; A Course in Calculus and Real Analysis (second edition); Springer.
2. R.R. Goldberg; Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi, 1970.
3. Calculus and Analytic Geometry (Ninth Edition); Thomas and Finney; Addison-Wesley, Reading Mass., 1998.
4. T. Apostol; Calculus Vol. 2; John Wiley.
5. Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student Edition).
6. Serge Lang, Introduction to Linear Algebra, Springer.
7. S Kumaresan, Linear Algebra - A Geometric Approach, PHI Learning

Additional References:

1. Ajit Kumar, S.Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014
2. D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.
3. K. Stewart; Calculus, Booke/Cole Publishing Co, 1994.
4. J. E. Marsden, A.J. Tromba and A. Weinstein; Basic Multivariable Calculus; Springer.
5. R.G. Brtle and D. R. Sherbert; Introduction to Real Analysis Second Ed. ; John Wiley, New Yorm, 1992.
6. M. H. Protter; Basic Elements of Real Analysis; Springer-Verlag, New York, 1998.
7. Sheldon Axler, Linear Algebra done right, Springer.
8. Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers.

Course Code	MINOR	Credits	Lectures/Week
24MATMR321	ORDINARY DIFFERENTIAL EQUATIONS	2	2

Course Outcomes**:**

After successful completion of this course, students would be able to

CO1:Recall the ideas of first order first degree differential equation to go into the higher order linear and ordinary differential equations.

CO2:Understand different types of methods to solve higher order linear differential equations and ordinary differential equations numerically.

CO3:Apply the concepts of Higher Order Linear Differential equations , numerical solutions of ordinary differential equations and numerical solution of simultaneous and higher order ordinary differential equations to solve related problems.

CO4:Solve higher order linear differential equations and ordinary differential equations using Taylor's series method, Picard's method, Eulers method, Modified Eulers method, Runge Kutta method of second and fourth order for ordinary and simultaneous ordinary differential equations.

Unit	Topics	No of Lectures
I	**Higher order Linear Differential equations** 1. The general n−th order linear differential equations, Linear independence, An existence and uniqueness theorem, the Wronskian, Classification: homogeneous and non-homogeneous, General solution of homogeneous and non-homogeneous LDE, The Differential operator and its properties. 2. Higher order homogeneous linear differential equations with constant coefficients, the auxiliary equations, Roots of the auxiliary equations: real and distinct, real and repeated, complex and complex repeated. 3. Higher order homogeneous linear differential equations with constant coefficients, the method of undermined coefficients, method of variation of parameters. 4. The inverse differential operator and particular integral, Evaluation of $\frac{1}{f(D)}$ for the functions like e^{ax}, sin ax, cos ax, x^m, $x^m \sin sin\, ax$, $x^m \cos cos\, ax$, $e^{ax}V$ and xV where V is any function of x. 5.Higher order linear differential equations with variable coefficients: The Cauchy's equation:	**15**

	$x^3\frac{d^3y}{dx^3} + x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} + y = f(x)$ and The Legendre's equation: $(ax+b)^3\frac{d^3y}{dx^3} + (ax+b)^2\frac{d^2y}{dx^2} + (ax+b)\frac{dy}{dx} + y = f(x).$	
II	**Numerical Solution of Ordinary Differential Equations** 1. Numerical Solution of initial value problem of first order ordinary differential equation using: (i) Taylor's series method, (ii) Picard's method for successive approximation and its convergence, (iii) Euler's method and error estimates for Euler's method, (iv) Modified Euler's Method, (v) Runge-Kutta method of second order and its error estimates, (vi) Runge-Kutta fourth order method. 2. Numerical solution of simultaneous and higher order ordinary differential equation using: (i) Runge-Kutta fourth order method for solving simultaneous ordinary differential equation, (ii) Finite difference method for the solution of two point linear boundary value problem.	**15**

References:
1. E.D. Rainville and P.E. Bedient; Elementary Differential Equations; Macmillan.
2. M.D. Raisinghania; Ordinary and Partial Differential Equations; S. Chand.
3. G.F. Simmons; Differential Equations with Applications and Historical Notes; Taylor's and Francis.

Additional References:
1. K. Atkinson, W.Han and D Stewart, Numerical Solution of Ordinary Differential Equations, Wiley.
2. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI.

Course Code	PRACTICAL MINOR	Credits	Lectures/ Week
24MATMRP321	ORDINARY DIFFERENTIAL EQUATIONS	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Describe different types of methods to solve higher order linear differential equations and ordinary differential equations..

CO2:Discuss the concepts of Higher Order Linear Differential equations , numerical solutions of ordinary differential equations and numerical solution of simultaneous and higher order ordinary differential equations to solve related problems.

CO3: solve the problems based on the syllabus.

CO4:Relate mathematics and its applications in pure and applied sciences.

The Practicals should be performed either using non-programable scientific calculators

Sr. no.	Practical Details	No of Lectures/Hours
1	General solution of homogeneous and non-homogeneous LDE, Differential operator and its properties	60
2	Higher order homogeneous linear differential equations with constant coefficients, the auxiliary equations.	
3	Higher order homogeneous linear differential equations with constant coefficients, the method of undermined coefficients, method of variation of parameters.	
4	The inverse differential operator and particular integral, Evaluation of $\frac{1}{f(D)}$ for the functions like e^{ax}, sin ax, cos ax.	
5	Evaluation of $\frac{1}{f(D)}$ for the functions like x^m, $x^m \sin sin\, ax$, $x^m \cos cos\, ax$, $e^{ax}V$ and xV where V is any function of x.	
6	Higher order linear differential equations with variable coefficients: The Cauchy's equation, The Legendre's equation.	
7	Miscellaneous Theory Questions based on Unit I	
8	Finding the numerical solution of initial value problems using Taylor's series method, Picard's method.	
9	Euler's method and error estimates for Euler's method, Modified Euler's Method.	
10	Runge-Kutta method of second order and its error estimates	
11	Runge-Kutta fourth order method.	
12	Numerical solution of simultaneous and higher order ordinary differential equation using: Runge-Kutta fourth order method for solving simultaneous ordinary differential equation,	
13	Finding the numerical solution of two point linear boundary value	

	problem using Finite difference method	
14	Miscellaneous Theory Questions based on Unit II	

References:

1. E.D. Rainville and P.E. Bedient; Elementary Differential Equations; Macmillan.
2. M.D. Raisinghania; Ordinary and Partial Differential Equations; S. Chand.
3. G.F. Simmons; Differential Equations with Applications and Historical Notes; Taylor's and Francis.

Additional References:

1. K. Atkinson, W.Han and D Stewart, Numerical Solution of Ordinary Differential Equations, Wiley.
2. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI.

Course Code	VOCATIONAL SKILL COURSE (VSC)	Credits	Lectures/ Week
24MATVC341	PRACTICAL: BASICS OF PYTHON	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Define fundamentals of python language.

CO2:Explain Keywords , Identifiers, Data types, Control structures, Functions of python language.

CO3:Apply various clauses, conditional statements, looping statement to write different programs of python.

CO4:Examine various methods , control statements, data types, functions of python.

Sr. No.	Practical Details	No of Lectures/ Hours
1	The Python Programming Language, History, features, Installing Python. Running Code in the Interactive Shell, IDLE. Input, Processing, and Output , Editing, Saving, and Running a Script,	60
2	Debugging : Syntax Errors, Runtime Errors, Semantic Errors, Experimental Debugging.	
3	Data types and expressions: Variables and the Assignment Statement , Program Comments and Doc strings . Data Types-Numeric integers & Floating-point numbers. Boolean, string. Mathematical operators +, - *, ** , %. PEMDAS.	
4	Arithmetic expressions, Mixed-Mode Arithmetic and type Conversion, type( ). Input( ), print( ), program comments. id( ), int( ), str( ), float( ).	
5	Definite Iteration: The for Loop, Executing statements a given number of times , Specifying the steps using range( ) , Loops that count down.	
6	Boolean and Comparison operators and Expressions, Conditional and alternative statements- Chained and Nested Conditionals: if, if-else, if-elif-else, nested if, nested if-else, compound Boolean Expressions.	
7	Strings: Accessing characters, indexing, slicing, replacing. Concatenation (+), Repetition (*).	
8	String methods- find, join, split, lower, upper. len( ).	
9	Lists – Accessing and slicing, Basic Operations (Comparison, +),List membership and for loop.	
10	Replacing element (list is mutable). List methods- append, extend, insert, pop, sort. Max( ), min( ). Tuples.	
11	Creating a Dictionary, Adding keys and replacing Values , dictionary - key( ), value( ), get( ), pop( ), popitem(),etc.	
12	Design with functions : Defining Simple Functions- Parameters and	

	Arguments, the return Statement, tuple as return value.	

References:

1. Fundamentals of Python First programs 2nd edition - Kenneth A Lambert, Cengage Learning India.
2. Doing Math with Python - Amit Saha, No starch ptress,

Additional References:

1. Problem solving and Python programming- E. Balgurusamy, TataMcGrawHill.
2. The Python Language Reference Manual (version 3.2), Guido van Rossum, and Fred L. Drake, Jr. (Editor) ,ISBN: 1906966141,Network Theory Ltd, 120 pages (Revised November 2006)
3. Simplifying Regular Expression Using Python by Abhishek Singh, ISBN: 1094777978, April 2019, 79 pages.
4. Python in a Nutshell, 3rd Edition by Alex Martelli, ISBN: 144939292X, O'Reilly Media, May 2017, 654 pages.
5. Python Pocket Reference, 5th Edition by Mark Lutz, ISBN: 1449357016, O'Reilly Media, February 2014, 264 pages.

SEMESTER IV

Course Code	MAJOR -I	Credits	Lectures/ Week
24MATMJ411	PAPER –I CALCULUS IV	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Define upper and lower Riemann sums and improper integrals.

CO2: Describe the fundamental characteristics of Riemann integrable functions and categorize various test kinds in order to talk about integral convergence.

CO3: Apply basic results to verify Reimann integrability and various techniques to verify integral convergence. Moreover, the area under the curve can be found using integration. Solve a variety of improper integrals by applying the ideas of beta and gamma functions.

CO4: Analyse various tests for integrable functions for creating counter examples and support the theory with applicable examples.

Unit	Topics	No of Lectures
I	**Riemann Integration** 1. Idea of approximating the area under a curve by inscribed and circumscribed rectangles. Partitions of an interval. Refinement of a partition. Upper and Lower sums for a bounded real valued function on a closed and bounded interval. Riemann integrability and the Riemann integral. 2. Criterion for Riemann integrability. Characterization of the Riemann integral as the limit of a sum. Examples. 3. Algebra of Riemann integrable functions. Also, basic results such as if $f: [a, b] \to \mathbb{R}$ is integrable, then (i) $\int_a^b f(x)\,dx = \int_a^c f(x)\,dx + \int_c^b f(x)\,dx.$ (ii) | f | is integrable and $\left\lvert \int_a^b f(x)\,dx \right\rvert \leq \int_a^b \lvert f(x) \rvert\,dx$ (iii) If $f(x) \geq 0$ for all $x \in [a, b]$ then $\int_a^b f(x)\,dx \geq 0.$ 4. Riemann integrability of a continuous function, and more generally of a bounded function whose set of discontinuities has only finitely many points. Riemann integrability of monotone functions.	15

II	**Applications of Integrations and Improper Integrals** 1. Area between the two curves. Lengths of plane curves. Surface area of surfaces of revolution. 2. Continuity of the function $F(x) = \int_a^x f(t)dt$, $x \in [a, b]$ when $f: [a, b] \longrightarrow \mathbb{R}$ is Riemann integrable. First and Second Fundamental Theorems of Calculus. 3. Mean value theorem, Integration by parts formula. Leibnitz's Rule. 4. Definition of two types of improper integrals. Necessary and sufficient conditions for convergence. 5. Absolute convergence. Comparison and limit comparison tests for convergence. 6. Gamma and Beta functions and their properties. Relationship between them (without proof).	**15**

References:

1 Sudhir Ghorpade, Balmohan Limaye; A Course in Calculus and Real Analysis (second edition); Springer.

2 Robert G. Bartle, Donald R. Sherbert Introduction To Real Analysis; Wiley (2000).

3 R.R. Goldberg; Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi, 1970.

4 Calculus and Analytic Geometry (Ninth Edition); Thomas and Finney; Addison-Wesley, Reading Mass., 1998.

5 T. Apostol; Calculus Vol. 2; John Wiley.

Additional References:

1 Ajit Kumar, S.Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014

2 D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.

3 K. Stewart; Calculus, Booke/Cole Publishing Co, 1994.

4 M. H. Protter; Basic Elements of Real Analysis; Springer-Verlag, New York, 1998..

Course Code	MAJOR II	Credits	Lectures/ Week
24MATMJ411	LINEAR ALGEBRA II	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Understand the concepts of vector spaces, subspace, Direct sums of vector spaces,Quotient space, Basis of a vector space over R , linear transformation , Kernel and Range of Linear transformation and isomorphism.

CO2:Explain Examples of vector spaces, . Intersections and sums of subspaces, . Linear combination of vectors, . Basis of a vector space , elementary properties of Linear Transformations, Rank Nullity theorem.

CO3:Apply the concepts vector spaces , Linear transformations to solve related problems .

CO4:Relate Vector spaces, matrices and linear transformations.

Unit	Topics	No of Lectures
I	**Vector space over R** 1. Definition of a vector space over R. Subspaces; criterion for a nonempty subset to be a subspace of a vector space. Examples of vector spaces, including the Euclidean space $\mathbb{R}^n$, lines, planes and hyperplanes in $\mathbb{R}^n$ passing through the origin, space of systems of homogeneous linear equations, space of polynomials, space of various types of matrices, space of real valued functions on a set. 2. Intersections and sums of subspaces. Direct sums of vector spaces. Quotient space of a vector space by its subspace. 3. Linear combination of vectors. Linear span of a subset of a vector space. Definition of a finitely generated vector space. Linear dependence and independence of subsets of a vector space. 4. Basis of a vector space. Basic results that any two bases of a finitely generated vector space have the same number of elements. Dimension of a vector space. Examples. Bases of a vector space as a maximal linearly independent sets and as minimal generating sets.	**15**
II	**Linear Transformations** 1. Definition of a linear transformation of vector spaces; elementary properties. Examples. Sums and scalar multiples of linear	**15**

	transformations. Composites of linear transformations. A Linear transformation of $V \rightarrow W$, where V, W are vector spaces over R and V is a finite-dimensional vector space is completely determined by its action on an ordered basis of V. 2. Null-space (kernel) and the image (range) of a linear transformation. Nullity and rank of a linear transformation. Rank-Nullity Theorem (Fundamental Theorem of Homomorphisms). 3. Matrix associated with linear transformation of $V \rightarrow W$ where V and W are finite dimensional vector spaces over R.. Matrix of the composite of two linear transformations. Invertible linear transformations (isomorphisms), Linear operator, Effect of change of bases on matrices of linear operator.	

References:
1 Howard Anton, Chris Rorres; Elementary Linear Algebra; Wiley Student Edition).
2 Serge Lang; Introduction to Linear Algebra; Springer.
3 S Kumaresan; Linear Algebra - A Geometric Approach; PHI Learning.
4 Gareth Williams; Linear Algebra with Applications; Jones and Bartlett Publishers.
Additional References:
1 David W. Lewis; Matrix theory
2 Sheldon Axler; Linear Algebra done right; Springer.

Course Code	PRACTICAL MAJOR	Credits	Lectures/ Week
24MATMJP41	PAPER I & PAPER II (CALCULUS IV& LINEAR ALGEBRA II)	4	8

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Describe basic results to verify Reimann integrability and various techniques to verify integral convergence, the concepts vector spaces , Linear transformations

CO2: Understand various tests for integrable functions for creating counter examples and support the theory with applicable examples, Vector spaces, matrices and linear transformations

CO3: solve the problems based on the syllabus.

CO4: Relate mathematics and its applications in pure and applied sciences.

GROUP A: CALCULUS IV

Sr. no.	Practical Details	No of Lectures/ Hours
1	Calculation of upper sum, lower sum using definition.	60
2	Examples based on Riemann integrals.	
3	Problems on properties of Riemann integral.	
4	Examples on Riemann integration as a limit of sum.	
5	Examples on algebra of Riemann integrable functions.	
6	Problems based on Riemann integrability of a continuous function, more generally of a bounded function whose set of discontinuities has only finitely many points and monotone functions.	
7	Problems on fundamental theorem of calculus.	
8	Problems on mean value theorems, integration by parts and Leibnitz rule.	
9	Examples of area under the curve and length of plane curves.	
10	Examples of area of surface revolution.	
11	Problems on convergence/divergence of improper integrals of type I.	
12	Problems on convergence/divergence of improper integrals of type II.	
13	Problems on beta and gamma functions.	
14	Miscellaneous Theory Questions based on full paper.	

GROUP B: LINEAR ALGEBRA II		
1	Problems on vector spaces .	60
2	Subspace of a vector space	
3	Problems on intersections and sums of subspaces, direct sums of vector spaces and quotient space of a vector space by its subspace.	
4	Problems on linear combination of vectors and Linear span of a subset of a vector space.	
5	Problems on linear dependence and linear independence.	
6	Problems on Basis and Dimension.	
7	Miscellaneous Theory Questions based on Unit I	
8	Linear transformation of vector space.	
9	Composites of linear transformations	
10	Problems on Kernel, Image and Rank-Nullity Theorem.	
11	Linear Isomorphism, Matrix associated with Linear transformations	
12	Invertible linear transformations and linear operator.	
13	Problems on effect of change of bases on matrices of linear operator.	
14	Miscellaneous Theory Questions based on unit II	

References:

1. Sudhir Ghorpade, Balmohan Limaye; A Course in Calculus and Real Analysis (second edition); Springer.
2. Robert G. Bartle, Donald R. Sherbert Introduction To Real Analysis; Wiley (2000).
3. R.R. Goldberg; Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi, 1970.
4. Calculus and Analytic Geometry (Ninth Edition); Thomas and Finney; Addison-Wesley, Reading Mass., 1998.
5. T. Apostol; Calculus Vol. 2; John Wiley.
6. Howard Anton, Chris Rorres; Elementary Linear Algebra; Wiley Student Edition).
7. Serge Lang; Introduction to Linear Algebra; Springer.
8. S Kumaresan; Linear Algebra - A Geometric Approach; PHI Learning.

Additional References:

1 Ajit Kumar, S.Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014

2 D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.

3 K. Stewart; Calculus, Booke/Cole Publishing Co, 1994.

4 M. H. Protter; Basic Elements of Real Analysis; Springer-Verlag, New York, 1998..

5 David W. Lewis; Matrix theory

6 Sheldon Axler; Linear Algebra done right; Springer.

Course Code	MINOR	Credits	Lectures/ Week
K23USMATMR421	NUMERICAL METHODS	2	2

Course Outcomes:

After successful completion of this course, students would be able to

CO1: Describe the types of errors and the theory of Algebric and Transcendental equations, Interpolation,numerical integration .

CO2: Identify the common numerical methods and use them to obtain approximate solutions

CO3: Apply numerical methods to obtain approximate solutions to mathematical problems and solve the problems of interpolation, numerical integration.

CO4: Analyze and apply different types of methods to solve problems related to algebraic and transcendental equations.

Unit	Topics	No of Lectures
I	**Solution of Algebraic and Transcendental Equations** 1. Measures of Errors: Relative, absolute and percentage errors, Accuracy and precision: Accuracy to n decimal places, accuracy to n significant digits or significant figures, Rounding and Chopping of a number, Types of Errors: Inherent error, Round-off error and Truncation error. 2. Iteration methods based on first degree equation: Newton-Raphson method. Secant method. Regula-Falsi method. Derivations and geometrical interpretation and rate of convergence of all above methods to be covered. 3. General Iteration method: Fixed point iteration method.	**15**
II	**Interpolation, Curve fitting, Numerical Integration** 1. Interpolation: Lagrange's Interpolation. Finite difference operators: Forward Difference operator, Backward Difference operator. Shift operator. Newton's forward difference interpolation formula. Newton's backward difference interpolation formula. Derivations of all above methods to be covered. 2. Curve fitting: linear curve fitting. Quadratic curve fitting. 3. Numerical Integration: Trapezoidal Rule. Simpson's 1/3 rd Rule. Simpson's 3/8th Rule. Derivations all the above three rules to be covered.	**15**

References:

1 Kendall E. and Atkinson; An Introduction to Numerical Analysis; Wiley.

2 M. K. Jain, S. R. K. Iyengar and R. K. Jain; Numerical Methods for Scientific and Engineering Computation; New Age International Publications.
3 S. Sastry; Introductory methods of Numerical Analysis; PHI Learning.

Additional References:

1 S.D. Comte and Carl de Boor; Elementary Numerical Analysis, An algorithmic approach; McGrawHillll International Book Company.
2 Hildebrand F.B.; Introduction to Numerical Analysis; Dover Publication, NY.
3 Scarborough James B.; Numerical Mathematical Analysis; Oxford University Press, New Delhi.

Course Code	PRACTICAL MINOR	Credits	Lectures/ Week
24MATMRP421	PRACTICAL NUMERICAL METHODS	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Understand different types of methods to solve problems related to algebraic and transcendental equations.

CO2:Discuss numerical methods to obtain approximate solutions to mathematical problems and solve the problems of interpolation, numerical integration.

CO3: solve the problems based on the syllabus.

CO4: Relate mathematics and its applications in pure and applied sciences.

The Practical no. 1 to 5 should be performed either using non-programable scientific calculators

Sr. No.	Practical Details	No of Lectures/ Hours
1	Measures of Errors: Relative, absolute and percentage errors,	60
2	Accuracy and precision, Types of Errors	
3	Newton-Raphson method	
4	Secant method.	
5	Regula-Falsi method, Fixed point Method.	
6	Fixed point Method.	
7	Miscellaneous Theory Questions based on Unit I	
8	Interpolating polynomial by Lagrange's Interpolation.	
9	Finite difference operators: Forward Difference operator, Backward Difference operator. Shift operator.	
10	Newton forward and backward difference Interpolation.	
11	Curve fitting: linear curve fitting. Quadratic curve fitting	
12	Numerical Integration :Trapezoidal Rule, Simpson's 1/3rd Rule, Simpson's 3/8th Rule.	
13	More problems on practical 12	
14	Miscellaneous Theory Questions based on Unit II	

References:

4 Kendall E. and Atkinson; An Introduction to Numerical Analysis; Wiley.

5 M. K. Jain, S. R. K. Iyengar and R. K. Jain; Numerical Methods for Scientific and Engineering Computation; New Age International Publications.

6 S. Sastry; Introductory methods of Numerical Analysis; PHI Learning.

Additional References:

4 S.D. Comte and Carl de Boor; Elementary Numerical Analysis, An algorithmic approach; McGrawHillll International Book Company.

5 Hildebrand F.B.; Introduction to Numerical Analysis; Dover Publication, NY.

Scarborough James B.; Numerical Mathematical Analysis; Oxford University Press, New Delhi.

Course Code	SKILL ENHANCEMENT COURSE (SEC)	Credits	Lectures/ Week
24MATSE451	QUANTITATIVE APTITUDE AND LOGICAL REASONING -III	2	4

Course Outcomes:

After successful completion of this course, students would be able to

CO1:Define Profit and loss, Ratio and proportion, Partnership, speed and distance, Simple interest and compound interest.

CO2:Describe Profit and loss, Ratio and proportion, Partnership, speed and distance, Simple interest and compound interest.

CO3:Solve problems of Profit and loss, Ratio and proportion, Partnership, speed and distance, Mixture and Alligation ,Simple interest and compound interest and series .

CO4:Illustrate various techniques involved in solving mathematical problems and thereby reducing the time taken for performing related calculation .

Sr. No.	Practical Details	No of Lectures/ Hours
1	Profit and loss: Cost price , selling price, profit or gain, loss.	
2	Ratio and proportion: Ratio, proportion, forth proportional, third proportional, mean proportional	60
3	Comparison of ratios, compounded ratio, duplicate ratio, sub-duplicate ratio, triplicate ratio, sub-triplicate ratio.	
4	Variation, direct proportion, indirect proportion.	
5	Partnership, Ratio of division of gains: simple partnership,	
6	Compound partnership, working and sleeping partner.	
7	Pipes and Cisterns: problems based on Inlet and outlet.	
8	Problems based on Time, work and efficiency, speed and distance	
9	Problems on trains.	
10	Boat and Streams : Upstreams and Downstreams, speed in still water.	
11	Mixture and Alligation, Mean price, rules of allegation.	
12	Simple interest and compound interest,	
13	Interest is compounded annually but time is in fraction, rates are different for different years.	
14	Logical Reasoning: Mathematical operations , coding-decoding, odd man out and series	

References:

1 Quantitative Aptitude for competitive examinations by Dr. R.S.Aggarwal S.Chand Publication

2 Quantitative Aptitude for the CAT by Arun Sharma , TATA McGRAW-HILL's Series.

Additional References:

1 Quantitative Aptitude for competitive examinations by Abhijit Gupta TATA McGRAW-HILL Publishing company limited, New Delhi.

2 Quantitative Aptitude by P.R. Vittal pearson education Publication.

Evaluation Scheme for Second Year (UG) under NEP (2 credits)

I. Internal Evaluation for Theory Courses – 20 Marks

1) Continuous Internal Assessment(CIA) Assignment - Tutorial/ Case Study/ Project / Presentations– 10 marks

2) Continuous Internal Assessment(CIA) ONLINE Unit Test – 10 marks

II. External Examination for Theory Courses – 30 Marks

Duration: 1 Hour

Theory question paper pattern: All questions are compulsory.

Question	Based on	Marks
Q.1	Unit I	15
Q.2	Unit II	15

- All questions shall be compulsory with internal choice within the questions.
- Each Question may be sub-divided into sub questions as a, b, c, d, etc. & the allocation of Marks depends on the weightage of the topic.

III. Practical Examination

- Each core subject carries 50 Marks.
- Duration: 2 Hours for each practical course.
- Minimum 80% practical from each core subjects are required to be completed.
- Certified Journal is necessary for appearing at the time of Practical Exam

NOTE: To pass the examination, attendance is compulsory in both Internal & External (Theory + Practical) Examinations.

PASSING STANDARD NEP Second Year : · The learners /students shall obtain minimum of 40% marks in the Internal Assessment and External Assessment (Semester End Examination) COMBINED, to pass the course in a particular semester. A learner / student will be said to have passed the course if He/She passes the Internal Assessment + Semester End Examination COMBINED.

· To pass the examination attendance is compulsory in both internal and external (theory plus practical) examination.

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