Mangalore University

Mangalagangothri -574 199

SYLLABUS

V and VI Semester
B.A./B.Sc. (Hons) Mathematics,

(ACCORDING TO NATIONAL EDUCATION POLICY 2020)

2023

Name of the Degree Program : **B.A./B.Sc.**
Discipline Course : **Mathematics**
Starting Year of Implementation : **2021-22 (I & II Semesters)**
2022-23 (III & IV Semesters)
2023-24 (V & VI Semesters)

Assessment

Weightage for the Assessments (in percentage)

Type of Course	Formative Assessment/ I.A.	Summative Assessment (S.A.)
Theory	40%	60 %
Practical	50%	50 %
Projects	40 %	60 %
Experiential Learning (Internship etc.)	--	--

Courses Offered

Semester	Course No.	Theory/ Practical	Credits	Paper Title	Marks in percentage	
					S. A.	I.A.
V	MATDSCT5.1	Theory	4	Real Analysis-II and Complex Analysis	60	40
	MATDSCP5.1	Practical	2	Theory based Practicals on Real Analysis-II and Complex Analysis	25	25
	MATDSCT5.2	Theory	4	Algebra and Graph Theory	60	40
	MATDSCP5.2	Practical	2	Theory based Practicals on Algebra and Graph Theory	25	25
VI	MATDSCT6.1	Theory	4	Linear Algebra	60	40
	MATDSCP6.1	Practical	2	Theory based Practicals on Linear Algebra	25	25
	MATDSCT6.2	Theory	4	Numerical Analysis	60	40
	MATDSCP6.2	Practical	2	Theory based Practicals on Numerical Analysis	25	25

Syllabus for B.A./B.Sc. with Mathematics

SEMESTER – V

MATDSCT 5.1: Real Analysis-II and Complex Analysis	
Teaching Hours : 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 60 Hours	**Max. Marks: 100 (S.A.-60 + I.A. – 40)**

Course Learning Outcomes:

The overall expectation from this course is that the student builds a basic understanding on Riemann integration and elementary complex analysis. The broader course outcomes are listed as follows. At the end of this course, the student will be able to:

1. Carry out computations of upper and lower Riemann sums as well definite integrals.
2. Describe various criteria for Integrability of functions.
3. Evaluate some improper integrals and Evaluate double integrals by using Beta, Gamma functions.
4. Exhibit certain properties of mathematical objects such as integrable functions, analytic functions, harmonic functions and so on.
5. Prove some statements related to Riemann integration as well as in complex analysis.
6. Carry out the existing algorithms to construct mathematical structures such as analytic functions.
7. Evaluate complex line integrals using definition and some well known theorems.
8. Apply the gained knowledge to solve various other problems.

Real Analysis-II

Unit – I: Riemann Integration

Definition and Existence of the Integral, Riemann Darboux Sums - Upper and lower (Darboux) sums - definition, properties and problems. Riemann Integral - Upper and Lower integrals (definition & problems), Inequalities for Integrals, Refinement of Partitions, Darboux's theorem, Conditions of Integrability, Integrability of Sum, Difference, Product, Quotient and Modulus of integrable functions. Integral as a limit of sum (Riemann sums), Some Applications, Some Integrable Functions – Integrability of continuous functions, monotonic functions, bounded function with finite number of discontinuity.

15 Hour

Unit –II: Improper Integrals

Improper integrals of the first, second and third kind with examples. Improper integral as the limit of the proper integral. Comparison test, Abel's test and Dirichlet's test for the convergence of the integral of a product of two functions. Beta, Gamma functions - Definitions, properties and examples, Relations between Beta and Gamma functions, Applications to evaluation of definite integrals, Duplication formula and applications.

15 Hours

Complex Analysis

Unit – III: Complex numbers and functions of complex variables:

Complex numbers: Sums and Products, Basic Algebraic Properties, Further Properties, Vectors and Moduli, Complex Conjugates, Exponential Form, Products and Powers in Exponential Form, Arguments of Products and Quotients, Roots of Complex Numbers, and examples, Regions in the complex plane.

Analytic Functions: Functions of a Complex Variable, Mappings, Mappings by the Exponential Function, Limits, Theorems on Limits, Limits Involving the Point at Infinity, Continuity, Derivatives, Differentiation Formulas, Cauchy–Riemann Equations, Sufficient Conditions for Differentiability, Polar Coordinates, Analytic Functions and examples, Harmonic Functions.

15 Hours

Unit –IV: Complex Integration

Derivatives and Definite Integrals of Complex valued Functions of Real Variable, Contours, and Contour Integrals with Examples, Examples with Branch Cuts, Upper Bounds for Moduli of Contour Integrals, Antiderivatives, Cauchy–Goursat Theorem, Simply Connected Domains, Multiply Connected Domains, Cauchy Integral Formula, An Extension of Cauchy Integral Formula, Some Consequences of the Extension.

15 Hours

Reference Books:

[1] S.C. Malik and Savita Arora, *Mathematical Analysis*, 2nd ed. New Delhi, India: New Age international (P) Ltd.

[2] Maurice D. Weir, George B. Thomas, Jr., Joel Hassand Frank R. Giordano, Thomas' Calculus, 11th Ed., Pearson, 2008.

[3] R.V. Churchil & J.W. Brown, *Complex Variables and Applications*, 5th ed, McGraw Hill Companies.

[4] S.C Malik, *Real Analysis,* New Age International (India) Pvt. Ltd.

[5] Richard R Goldberg, *Methods of Real Analysis*, Oxford and IBH Publishing.

[6] Ajit Kumar and S. Kumaresan - *A Basic Course in Real Analysis*, Taylor and Francis Group.

[7] L. V. Ahlfors, *Complex Analysis*, 3rd Edition, McGraw Hill Education.

[8] Bruce P. Palka , *Introduction to the Theory of Function of a Complex Variable*, Springer

[9] Serge Lang, *Complex Analysis*, Springer.

[10] Shanthinarayan, *Theory of Functions of a Complex Variable,* S. Chand Publishers.

[11] S. Ponnuswamy, *Foundations of Complex Analysis*, 2nd Edition, Alpha Science International Limited.

[12] Grewal, B. S., & Grewal, J. S. (1996). Higher engineering mathematics. 42nd Ed., Khanna Publishers, New Delhi.

[13] Shanthi Narayan, P. K. Mittal (2004), Theory of Functions of a Complex Variable, Revised Ed. S. Chand and Company Ltd. New Delhi.

MATDSCP 5.1: Practicals on Real Analysis-II and Complex Analysis	
Practical Hours : 4 Hours/Week	**Credits: 2**
Total Practical Hours: 60 Hours	**Max. Marks: 50 (S.A.-25 + I.A. – 25)**

Course Learning Outcomes: This course will enable the students to

1. Learn *Free and Open Source Software* (FOSS) tools for computer programming
2. Solve problem on Real Analysis and Complex Analysis studied in MATDSCT 5.1 by using FOSS softwares.
3. Acquire knowledge of applications of Real Analysis and Complex Analysis through FOSS.

Practical/Lab Work to be performed in Computer Lab

Suggested Software: Maxima/Scilab/Python/R.
Suggested Programs:

1. Program to find upper and lower Riemann sums with respect to given partition
2. Program to test Riemann Integrability.
3. Program to evaluate Riemann integral as a limit of sum.
4. Program to check the convergence of the given improper integral using Abel's test.
5. Program to check the convergence of the given improper integral using Dirichlet's test.
6. Programs to evaluate improper integrals using Beta/Gamma Functions.
7. Program to illustrate applications of duplication formula for Beta/Gamma functions.
8. Program to find the nth roots of a given complex number.
9. Program on verification of Cauchy – Riemann equations (Cartesian form) or test for analyticity.
10. Program on verification of Cauchy – Riemann equations (Polar form) or test for analyticity.
11. Program to check whether a function is harmonic or not.
12. Program to construct analytic functions (through Milne–Thompson method).
13. Program to evaluate Definite Integrals of Complex valued Functions of Real Variable.
14. Program to illustrate evaluation of integrals using Cauchy's integral theorem.

MATDSCT5.2: Algebra and Graph Theory	
Teaching Hours : 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 60 Hours	**Max. Marks: 100 (S.A.-60 + I.A. – 40)**

Course Learning Outcomes: The overall expectation from this course is that the student builds a basic understanding on the theory of groups and some elementary concepts of graph theory. This course will enable the students to:

1. Know the significance of normal subgroups and quotient groups.
2. Understand structure preserving mapping between two algebraic structures of the same type.
3. Know the algebraic structures having the same structure with different elements.
4. Identify and analyze the algebraic structures such as ring, field and integral domain
5. Know the basic terminologies used in the theory of graphs.
6. Study the graphs which are used to model pair wise relations between the objects which will help in understanding the networking, optimization, matching and operation.
7. Understand the importance of cutsets, connectivity, planarity and colorability in the theory of graphs.
8. Apply graph theoretic tools to solve real life problems.

Algebra

Unit I: More on Groups

Congruence relation in subgroups, Cosets, Theorem on cosets, Lagrange's theorem and applications, Index of a subgroup, Normal Subgroups, Quotient groups. Homomorphism, Kernel of a homomorphism, Isomorphism, First Isomorphism theorem, Automorphisms. Permutation groups, Cycles, Transpositions, Type of permutations, Length of a cycle, Index of S_n, Alternating group, Order of a permutation.

15 hours

Unit II: Rings, Integral Domains, Fields

Rings : Definition and examples, Commutative Rings, Subrings, Integral Domain, Division Ring, Fields, Properties of Rings, Characteristic of an Integral Domain, Homomorphism, Kernel, Isomorphism, Ideals, First Isomorphism theorem in Rings, Prime and Maximal Ideals, Quotient Rings.

15 hours

Graph Theory

Unit III: Basics of Graph Theory

Graphs, Finite and infinite graphs, Incidence and degree, Isolated vertex, Pendent vertex, Null graph, Isomorphism, Sub graph, Walks, Paths, Circuits, Connected and Disconnected graphs, components, Euler graphs, Operation on graphs, Hamiltonian paths, Circuits, Tees and some properties of trees, Rooted and Binary trees, Spanning tree and Fundamental circuit.

15 hours

Unit IV: Connectivity, Planar Graphs and Coloring

Cutsets, Properties, Fundamental cut sets, Connectivity, and Separability. Planar graphs, Kuratowski's graphs, Different representation of planar graphs, Geometric duel. Graph Coloring: Chromatic number and Chromatic polynomials.

15 hours

Reference Books

[1] I N Herstein (1990), Topics in Algebra, 2nd Edition, Wiley Eastern Ltd., New Delhi.

[2] Vijay K Khanna and S K Bhambri (1998), A Course in Abstract Algebra, Vikas Publications.

[3] Michael Artin (2015), Algebra, 2nd ed., Pearson.

[4] Joseph A, Gallian (2021), Contemporary Abstract Algebra, 10th ed., Taylor and Francis Group.

[5] C. L. Liu (2000), Elements of Discrete Mathematics, Tata McGraw-Hill.

[6] Hari Kishan and Shiv Raj Pundir (2015), Discrete Mathematics, Pragathi Prakashan, 10th ed.

[7] W D Wallis (2017), A Beginner's Guide to Discrete Mathematics for Computer Science, Wiley Publishers.

[8] Kenneth H. Rossen, Discrete Mathematics and its Applications, Mc-Graw Hill, 8th ed., 2021.

[9] Frank Harary (1969), Graph Theory, Addison-Wesley Pub. Company.

[10] N. Deo (1990), Graph Theory: Prentice Hall of India Pvt. Ltd. New Delhi.

[11] D B West (2001), Introduction to graph theory 2nd Ed., Pearson.

MATDSCP5.2: Practicals Algebra and Graph Theory	
Teaching Hours : 4 Hours/Week	Credits: 2
Total Teaching Hours: 60 Hours	Max. Marks: 50 (S.A.-25 + I.A. – 25)

Course Learning Outcomes: This course will enable the students to

1. Learn *Free and Open Source Software (FOSS)* tools for computer programming
2. Solve problems related to Algebra and Graph Theory using FOSS software.

Practical/Lab Work to be performed in Computer Lab (FOSS) Suggested Software: Maxima/Scilab /Python/R.

Suggested Programs:

1. Verification of Lagrange's theorem
2. Examples to find left and right cosets and finding index of a group
3. Finding all Normal Subgroups of a group.
4. Finding whether a given Permutation is even and odd and its order.
5. Checking whether a given set is a ring with respect to given binary operations.
6. Checking whether a given set is an integral domain or field with respect to given binary operations.
7. Finding zero divisors and units in finite rings.
8. Verification of the given mapping for ring homomorphism.
9. Drawing some standard graphs like Dodecahedron, wheel graph, Peterson graph.
10. Checking planarity, finding number of edges, vertex and edge connectivity, center, radius, and diameter.
11. Checking for Hamiltonian path/circuit in a graph.
12. Checking for Eulerian path/cycle in a graph.
13. Finding shortest path between two vertices.
14. Finding vertex coloring and redrawing the graph with colouring for vertices and finding chromatic number.

SEMESTER – VI

MATDSCT 6.1: Linear Algebra	
Teaching Hours : 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 60 Hours	**Max. Marks: 100 (S.A.-60 + I.A. – 40)**

Course Learning Outcomes:

The overall expectation from this course is that the student will build a basic understanding in few areas of linear algebra such as vector spaces, linear transformations and inner product spaces. Some broader course outcomes are listed as follows. At the end of this course, the student will be able to

1. Understand the concepts of Vector spaces, subspaces, bases dimension and their properties.
2. Find a basis and compute the dimension of a given finite dimensional vector space.
3. Use matrix representation of linear transformations in various computations.
4. Become familiar with the concepts Eigen values and Eigen vectors, minimal polynomials, linear transformations etc.
5. Learn properties of inner product spaces and determine orthogonality in inner product spaces.
6. Prove various statements in the context of vectors spaces.
7. Realize importance of adjoint of a linear transformation and its canonical form.
8. Apply the techniques of diagonalization in solving various problems related to matrices.

Unit – I: Vector spaces

Vector spaces - Definition, Examples and properties, Subspaces - Examples, Criterion for a sub- set to be a subspace and some properties. Linear Combination - Linear span, Linear dependence and Linear independence, Basic properties of linear dependence and independence, Techniques of determining linear dependence and independence in various vector spaces and related problems. Basis and dimension - Co-ordinates, Ordered basis, Some basic properties of basis and dimension and subspace spanned by given set of vectors, Quotient space, Dimension of quotient space (derivation in finite case). Sum and Direct sum of subspaces - Dimensions of sum and direct sum spaces (derivation in finite case).

15 Hours

Unit – II: Linear Transformations

Linear transformation - Definition, Examples, Equivalent criteria, Some basic properties, Matrix representation, Change of basis and effect on associated matrix, Similar matrices; Rank - Nullity theorem - Null space, Range space, Proof of rank nullity theorem and related problems.

15 Hours

Unit – III: Isomorphism, Eigenvalues and Diagonalization

Homomorphism, Isomorphism and automorphism - Examples, Order of automorphism and Fundamental theorem of homomorphism; Eigenvalues and Eigen vectors - Computation of eigen values, Algebraic multiplicity and some basic properties of eigen values, Determination of eigenvectors and eigen space and geometric multiplicity. Diagonalizability of linear transformation - Meaning, Condition based on algebraic and geometric multiplicity and related problems.

15 Hours

Unit – IV: Invertible Transformation and Inner product spaces

Invertible transformation - Some basic properties of invertible, singular and non-singular transformations, Conditions for existence of inverses, Minimal polynomial of a transformation, Relation between characteristic and minimal polynomials and related problems.

Inner product and normed linear spaces - Definitions, Examples, Cauchy-Schwartz inequality and related problems; Gram-Schmidt orthogonalization - Orthogonal vectors, orthonormal basis, Gram-Schmidt orthogonalization process.

15 Hours

Reference Books:

[1] I. N. Herstein, *Topics in Algebra*, 2nd Edition, Wiley.

[2] Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence (2003), Linear Algebra(4th Edition), Printice-Hall of India Pvt. Ltd.

[3] F. M. Stewart, *Introduction to Linear Algebra*, Dover Publications.

[4] S. Kumaresan, *Linear Algebra*, Prentice Hall India Learning Private Limited.

[5] Kenneth Hoffman & Ray Kunze (2015), Linear Algebra, (2nd Edition), PrenticeHall India Leaning Private Limited.

[6] Gilbert Strang (2015), Linear Algebra and its applications, (2nd Edition), Elsevier.

[7] Vivek Sahai & Vikas Bist (2013), Linear Algebra (2nd Edition) Narosa Publishing.

[8] Serge Lang (2005), Introduction to Linear Algebra (2nd Edition), Springer India.

[9] T. K. Manicavasagam Pillai and K S Narayanan, Modern Algebra Volume 2.

MATDSCP 6.1: Practicals on Linear Algebra	
Practical Hours : 4 Hours/Week	**Credits: 2**
Total Practical Hours: 60 Hours	**Max. Marks: 50 (S.A.-25 + I.A. – 25)**

Course Learning Outcomes: This course will enable the students to

1. Learn *Free and Open Source Software (FOSS)* tools for computer programming
2. Solve problem on Linear Algebra studied in MATDSCT 6.1 by using FOSS softwares.
3. Acquire knowledge of applications of Linear Algebra through FOSS.

Practical/Lab Work to be performed in Computer Lab (FOSS) Suggested Softwares: Maxima/Scilab /Python/R.

Suggested Programs:

1. Program to verify linear dependence and independence.
2. Program to find basis and dimension of the subspaces.
3. Program to verify if a function is linear transformation or not.
4. Program to find the matrix of linear transformation.
5. Program to illustrate the effect of change of basis on the matrix of linear transformation.
6. Program to check invertibility of the given linear transformation and finding the inverse if exists.
7. Program to find the Eigen values and Eigen vectors of a given linear transformation.
8. Program on Rank – nullity theorem.
9. Program to find the characteristic polynomial of given transformation.
10. Program to find the minimal polynomial of given transformation.
11. Program to find the algebraic multiplicity of the Eigen values of the given linear transformation.
12. Program on diagonalization.
13. Program to verify that the given basis is orthogonal or not.
14. Program to illustrate Gram-Schmidt orthogonalization process.

MATDSCT 6.2: Numerical Analysis	
Teaching Hours : 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 60 Hours	**Max. Marks: 100 (S.A.-60 + I.A. – 40)**

Course Learning Outcomes:

The overall expectation from this course is that the student will get equipped with certain numerical techniques for various computations such as finding roots, finding the integrals and derivatives, and finding solutions to differential equations. Some broader course outcomes are listed as follows. At the end of this course, the student will be able to

1. Compute approximate roots of algebraic and transcendental equations using iterations.
2. Describe various operators arising in numerical analysis such as difference operators, shift operators and so on.
3. Articulate the rationale behind various techniques of numerical analysis such as in finding roots, integrals and derivatives.
4. Reproduce the existing algorithms for various tasks as mentioned previously in numerical analysis.
5. Apply the rules of calculus and other areas of mathematics in justifying the techniques of numerical analysis.
6. Solve problems using suitable numerical technique.
7. Obtain approximate solutions to initial value problems using various numerical techniques.
8. Appreciate the profound applicability of techniques of numerical analysis in solving real life problems and also appreciate the way the techniques are modifiedto improve the accuracy.

Unit – I: Algebraic and Transcendental Equations

Solutions to algebraic and transcendental equations -Bisection method, Regula-Falsi method, Iterative methods, Newton-Raphson method and Secant method (Plain discussion of the rationale behind techniques and problems on their applications).

System of Linear Algebraic Equations: Direct Methods – Gauss elimination method, Gauss-Jordan elimination method and Tringularization method; Iterative methods – Jacobi method, Gauss-Jacobi method, Gauss- Seidal method.

15 Hours

Unit – II: Polynomial Interpolations

Finite differences - Forward, Backward differences and shift operators: definitions, properties and problems; Polynomial interpolation - Newton-Gregory forward and backward interpolation formulas, Gauss's Forward and backward interpolation formulas, Lagrange interpolation polynomial, Newton's divided differences and Newton's general interpolation formula (Discussion on setting up the polynomials and problems on their applications).

15 Hours

Unit-III: Numerical Differentiation and Integration

Formula for derivatives (till second order) based on Newton-Gregory forward and backward interpolations (Derivations and problems based on them). Numerical Integration - General quadrature formula, Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule (derivations for only general quadrature formula, trapezoidal rule and Simpson's $1/3^{rd}$ rule and problems on the applications of all formulas).

15 Hours

UNIT-IV: Numerical Solution of Ordinary Differential Equations

Introduction, Solution by Taylor's series method, Picard's method, Euler's method, Modified Euler's method, Runge-Kutta Methods, Predictor-Corrector Methods- Milne's method, Adam's Bashforth Method, Adam Moulton Method.

15 Hours

Reference Books :

1. S. S. Sastry, *Introductory methods of Numerical Analysis*, 5th Edition, PHI Learning Private Limited.
2. E. Isaacson and H. B. Keller, *Analysis of Numerical methods*, Dover Publications.
3. E Kreyszig, *Advanced Engineering Mathematics*, Wiley India Pvt. Limited.
4. B. S. Grewal, *Numerical Methods for Scientists and Engineers*, Khanna Publishers.
5. M. K. Jain, S. R. K. Iyengar and R. K. Jain, *Numerical Methods for Scientific and Engineering computation*, 4th Edition, New Age International
6. H. C. Saxena, *Finite Difference and Numerical Analysis,* S. Chand Publishers
7. B. D. Gupta, *Numerical Analysis*, Konark Publishers Pvt. Ltd.

MATDSCP 6.2: Practicals on Numerical Analysis	
Practical Hours : 4 Hours/Week	**Credits: 2**
Total Practical Hours: 60 Hours	**Max. Marks: 50 (S.A.-25 + I.A. – 25)**

Course Learning Outcomes: This course will enable the students to

1. Learn *Free and Open Source Software (FOSS)* tools for computer programming
2. Solve problem on numerical Analysis studied in **MATDSCT 6.2 by** using FOSS softwares.
3. Acquire knowledge of applications of Numerical Analysis through FOSS.

Practical/Lab Work to be performed in Computer Lab (FOSS)

Suggested Softwares: Maxima/Scilab /Python/R.

Suggested Programs:

1. Program to find root of an equation using Bisection, Regula-Falsi and Secant methods.
2. Program to find root of an equation using Newton-Raphson method.
3. Program to solve system of algebraic equations using Gauss-elimination method.
4. Program to solve system of algebraic equations using Gauss-Jordan method.
5. Program to solve system of algebraic equation using Gauss-Jacobi method.
6. Program to solve system of algebraic equation using Gauss-Seidel method.
7. Program to evaluate integral using Simpson's 1/3 and 3/8 rules.
8. Program to evaluate integral using Trapezoidal and Weddle rules
9. Program to find the sums of powers of successive natural numbers using Newton – Gregory technique.
10. Program to find differentiation at specified point using Newton-Gregory interpolation method.
11. Program to find the missing value of table using Lagrange method.
12. Program to find the solution of given initial value problem using Picard's method.
13. Program to find the solution of given initial value problem using Euler's method and Modified Euler's method.
14. Program to find the solution of given initial value problem using Runge-Kutta methods.

References

1. The Hundred-Page Machine Learning Book, Andriy Burkov, January 13, 2019.
2. Introduction to Machine Learning with Python: A Guide for Data Scientists 1st Edition by Andreas Müller, Sarah Guido, O'Reilly Media, November 15, 2016

List of Activities:

1. Introduction to Scikit, Numpy, Scipy and Tensor Flow
2. Linear Regression – Single Variable Linear Regression
3. Linear Regression – Multi Variable Linear Regression
4. Classification – Logistic Regression
5. Classification – Support Vector Machines (SVM)
6. Classification using Neural Networks
7. Unsupervised Learning – Principal Component Analysis (PCA)
8. Unsupervised Learning – K-Means Clustering