Courses for B.Sc. with Mathematics as Major Subject
& B.Sc. Mathematics
(V and VI Semester)

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 Practical's on Real Analysis-II and Complex Analysis	25	25
	MATDSCT5.2	Theory	4	Advanced algebra and Discrete Mathematics	60	40
	MATDSCT5.2	Practical	2	Theory based Practical's on Advanced algebra and Discrete Mathematics	25	25
	MATSEC5.1	Theory and Practical	3	Programming with Python	60	40
VI	MATDSCT6.1	Theory	4	Linear Algebra	60	40
	MATDSCP6.1	Practical	2	Theory based Practical's on Linear Algebra	25	25
	MATDSCT6.2	Theory	4	Numerical Analysis	60	40
	MATDSCP6.2	Practical	2	Theory based Practical's on Numerical Analysis	25	25
	MATSEC6.1		2	Internship		

SEMESTER–V

MATDSCT5.1:Real Analysis-II and Complex Analysis	
Teaching Hours: 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 60Hours	**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 follow. At the end of this course, the student will be able to:

1. Carry out certain computations such as computing upper and lower Riemann sums as well integrals.
2. Describe various criteria for Integrability of functions.
3. Exhibit certain properties of mathematical objects such as integrable functions, analytic functions, harmonic functions and so on.
4. Prove some statements related to Riemann integration as well as in complex analysis.
5. Carry out the existing algorithms to construct mathematical structures such as analytic functions.
6. Applies the gained knowledge to solve various other problems.

Unit–I: Riemann Integration-I

Definition & examples for partition of an interval, Refinement and Common refinement of a partition. Lower and Upper Riemann (Darboux) sums – definition, properties & problems. Riemann Integral– Lower and Upper integrals (definition & problems), Darboux's theorem and Criterion for Integrability, Integrability of sum, difference, product, quotient and modulus of integrable functions. **Integral as a limit of sum (Riemannsum)** –Problems. **Some integrable functions** –Integrability of continuous functions, monotonic functions, bounded function with finite number of discontinuity. Fundamental theorem of Calculus–related problems, change of variables, integration by parts, first and second mean value theorems of integral calculus. **15 Hours**

Unit–II:

Complex number – Cartesian and Polar form (Definitions, properties and problems)- Geometrical representation of complex plane (z-plane); Euler's formula, $e^{i\theta} = \cos\theta + i\sin\theta$. Separate the real and imaginary parts of some standard functions $\left(e^z, \sin z, \cos z, \log z \, etc\right)$. Dot and vector product of z_1 and z_2. Equation of a straight line and circle in a complex form and represent graphically (locus of a point). **Functions of a complex variable** - Limit of a function, Continuity and differentiability, Analytic functions, Singular points (definitions and related problems); Cauchy-Riemann equations – Cartesian and Polar forms – Proof & Problems, Necessary and sufficient condition for a function to be analytic (Statement only); Harmonic functions– Definition and problems; Properties of analytic functions - Various properties with

proofs; Construction of analytic functions: i)Milne Thomson Method (Only problems) ii)Using the concept of harmonic function. **15 Hours**

Unit–III: Complex integration

Complex integration– definition, Line integral, properties and problems. Cauchy's Integral theorem- proof using Green's theorem- direct consequences. Cauchy's Integral formula with proof-Cauchy's generalized formula for the derivatives with proof and applications for evaluation of simple line integrals. Cauchy's inequality- Proof, Livouville's theorem- Proof. **15 Hours**

Unit-IV: Transformations

Definition, Jacobian of a transformation- Identity transformation- Reflection- Translation- Rotation and Magnification- Inversion- Inverse points- Linear transformation- Definitions- Bilinear transformations- Cross- ratio of four points- Cross-ratio preserving property- Preservation of the family of straight lines and circles- Conformal mappings- Discussion of the transformations $w = z^2, w = \sin z, w = \cos z, w = e^z, w = \frac{z + \bar{z}}{2}$ etc. **15 Hours**

Reference Books:

1. Ajit Kumr and S. Kumaresan - *A Basic Course in Real Analysis*,Taylor and Francis Group.
2. Bruce P.Palka, *Introduction to the Theory of Function of a Complex Variable*, Springer
3. L.V.Ahlfors, *Complex Analysis*, 3rdEdition, Mc Graw Hill Education
4. Richard R Goldberg, *Methods of Real Analysis*, Oxford and IBH Publishing
5. R.V.Churchil & J.W.Brown, *Complex Variables and Applications*, 5th ed, Mc Graw Hill Companies.
6. Shanthinarayan, *Theory of Functions of a Complex Variable*, S. Chand Publishers.
7. Serge Lang, *Complex Analysis*, Springer
8. S.C.Malik and Savita Arora, *Mathematical Analysis*, 5thed.NewDelhi, India: New Age international(P)Ltd., 2017.
9. S.C.Malik, *Principles of Real Analysis*, New Age International (India) Pvt.Ltd., 4thEdition, 2018.
10. S.Ponnuswamy, *Foundations of Complex Analysis*, 2ndEdition, Alpha Science International Limited.

MATDSCP 5.1: Practical's 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 RealAnalysis and Complex Analysis studied in **MATDSCT5.1 by** using FOSS software's.
3. Acquire knowledge of applications of Real Analysis and Complex Analysis through FOSS.

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

Suggested Programs:

1. Program to check whether a given set of real numbers attains supremum or infimum.
2. Program to find upper and lower Riemann sums with respect to given partition.
3. Program to test Riemann Integrability.
4. Program to evaluate Riemann integral as a limit of sum.
5. Program on verification of Cauchy –Riemann equations (Cartesian form) or test for analyticity.
6. Program on verification of Cauchy –Riemann equations (Polar form) or test for analyticity.
7. Program to check whether a function is harmonic or not.
8. Program to construct analytic functions (through Milne–Thompson method)
9. Program to find Cross ratio of points and related aspects.
10. Program to find fixed points of bilinear transformations.
11. Program to verify De-Moivre's theorem.

MATDSCT 5.2: Advanced Algebra and Discrete Mathematics	
Teaching Hours: 4 Hours/Week	**Credits: 4**
Total Teaching Hours: 60 Hours	**Max. Marks: 100 (S.A.-60+I.A.–40)**

Course Learning Outcomes: This course will enable the students to:

1. **Identify and analyze different algebraic structures such as rings, fields, domains and so on.**
2. **Explore the properties of the above mentioned algebraic structures.**
3. **Carry out the prescribed algorithm to compute the GCD of polynomials, irreducibility of polynomials and so on.**
4. **Prove various statements related to algebraic structures.**
5. **Apply the gained knowledge to solve various other problems.**

Unit I : Rings and Fields

Rings – definition and properties of rings- integral domains- Fields-theorems and problems, Sub rings- Criterion for sub rings- theorems and problems on sub rings, Ideals –Algebra of Ideals- theorems- Principal ideals - examples and standard properties following the definition, Divisibility in an integral domain-theorems and problems, Units and Associates- theorems and problems. Quotient rings– examples and theorems- The field of quotients- theorems and problems. **15 Hours**

Unit II : Polynomial rings and Homomorphism

Homomorphism- Definitions and example, Kernel of a homomorphism- examples and related theorems. Isomorphism of a ring- examples and related theorems. Automorphism- problems. Fundamental Theorem of Homomorphism of Rings, Prime and Maximal idealsin a commutative ring – definition and examples. Polynomials over rings and fields (some standard properties), division algorithm (proof and problems), Greatest common divisor – Euclidian algorithm (problems); reducible and irreducible polynomials over fields (definition and problems); Eisenstein's criteria for reducibility – problems; Rational roots of a polynomial – Test - problems; **15 Hours**

Unit III: Vector algebra

Vectors – Scalars – Vector Field – Scalar field (definition and problems); – Vector differentiation – The vector differential operator Gradient – Divergence – Curl – Standard derivations –vector integration Green's theorem in plane (definition and problems). **15 Hours**

Unit IV: Basics of Graph theory

Basic definitions, Isomorphism, Subgraphs, Operations on graphs, Walks, Paths, Circuits, Connected and disconnected graphs, Euler graphs, Hamiltonian graphs, Some applications, Trees - basic properties, Distance, Eccentricity, center, Spanning trees, Minimal spanning tree.

15 Hours

Reference Books

1. C.L. Liu (200), Elements of Discrete Mathematics,Tata McGraw-Hill.
2. Frank Harary(1969), GraphTheory, Addison-Wesley Pub.Company.
3. Hari Kishan and Shiv Raj Pundir (2015), Discrete Mathematics, Pragathi Prakashan, 10thed.
4. I N Herstein (1990), Topics in Algebra, 2nd Edition,Wiley Eastern Ltd., New Delhi.
5. Joseph A, Gallian (2021), Contemporary Abstract Algebra, 10thed., Taylor and Francis Group.
6. Kenneth H.Rossen, Discrete Mathematics and its Applications, Mc-GrawHill, 8th ed., 2021.
7. Michael Artin (2015), Algebra, 2nded., Pearson.
8. Murray R Spiegel – Theory and problems of vector calculus.
9. N. Deo(1990), Graph Theory: Prentice, Hall of India Pvt.Ltd. New Delhi.
10. Shanthinarayan and J N Kapur – A text book of Vector calculus.
11. Vijay K Khanna and SK Bhambri (1998), A Course in Abstract Algebra,Vikas Publications.
12. W D Wallis (2017), A Beginner's Guide to Discrete Mathematics for Computer Science,Wiley Publishers.

MATDSCP 5.2: Practical's on Advanced Algebra and Discrete Mathematics	
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 **Advanced Algebra and Discrete Mathematics** studied in **MATDSCT 5.2 by** using FOSS software's.
3. Acquire knowledge of applications of **Advanced Algebra and Discrete Mathematics** through FOSS.

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

Suggested Programs:

1. (i) To Verify the given Ring is Commutative or not.
   (ii) To check the Presence of the Unity element in the Ring.
2. (i) To Verify the given Ring is a Field /Integral Domain or not.
   (ii) To Verify given set is a Sub ring of a Ring or not.
3. To Verify given function is a homomorphism or not.
4. (i) To verify the given polynomial is reducible or irreducible.
   (ii) To find the zeros of the given polynomial.
5. To find the G.C.D of any two polynomials.
6. (i) To find the Units of the given ring.
   (ii) To verify the given elements are Associates or not.
7. Graph Theory
8. Maxima program to obtain some standard graphs
9. Create a graph of your choice
10. Obtain Induced sub graph
11. Obtain random graph
12. To check the given are graphs are isomorphic or not
13. Obtain degree of each vertex
14. Obtain distance between vertices
15. Obtain eccentricity of vertices
16. Operation on graphs: Product of graphs
17. Maximum/Minimum degree vertices of the graph G and a vertex of maximum/minimum degree
18. Obtain radius and diameter of the graph
19. Obtain Edge connectivity and Vertex connectivity
20. Obtain minimum spanning tree
21. Obtain Adjacency matrix of the graph

MATSEC 5.1: Programming with Python	
Teaching Hours: 4 Hours/Week	**Credits: 3**
Total Teaching Hours: 60 Hours	**Max. Marks: 100 (S.A.-60+I.A.–40)**

Course Learning Outcomes: On the completion of this course the students will be able to

1. Learn the syntax and semantics of Python programming language.
2. Write Python functions to facilitate cod reuse and manipulate strings.
3. Understanding the use of built-in functions to navigate the file system.
4. Apply the concepts of file handling.

Unit-I: Introduction, Basics and Program flow

Python character set, Tokens, variables and assignments, print statement, comments, Python data structure and data types, string operation in Python, simple input and out put, range function, iteration/looping statements, string and list manipulation, tuples, dictionaries, sorting techniques. **15 hours**

Unit-II: Functions, libraries and File handling

Understanding and creating your own functions, Function parameters, flow of execution in a function call, passing parameters, returning values from functions, scope of a function, importing modules in a python, using standard library functions and modules, creating a python library, data files, operating and closing files, working with text files, standard, input, output and error streams, working with binary and CSV files. **15 hours**

Unit-III: Practical implementation of python

1. Write python programs using the concept of control structures.
2. Implement python programs using functions and strings.
3. Implent methods to create and manipulate lists, tuples and dictionaries.
4. Apply the concept of file handling and reg Ex using packages.
5. Illustrate the working of scraping websites with CSV.

30 hours

Reference Books:

1. Automate the Boring Stuff with Python- AISweigart, William Pollock, 2015.
2. Basic Python programming for Beginners- Varada rajkumar, Marapalli Krishna, Jayprakash, Blue rose Publishers, 2022.
3. Learning Python- MarkLutz, O'Reilly Media, Paperback, 2nd edition, 2020.
4. Programming and problem solving through Python- Sathish jain and Shashi singh, BPB Publications, 2020.
5. Python Cook Book- David Beazely and Brain K. Jones, 2022.
6. Python- John Shovic and Alan Simpson, Paperback, 2020.

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

2. Understand the concepts of Vector spaces, subspaces, bases dimension and their properties.
3. Become familiar with the concepts Eigen values and Eigen vectors, minimal polynomials, linear transformations etc.
4. Learn properties of inner product spaces and determine orthogonality in inner product spaces.
5. Prove various statements in the context of vector spaces.
6. Realize importance of adjoint of a linear transformation and its canonical form.

Unit–I:Vector spaces

Vector spaces - Definition, examples and properties; Subspaces - Examples, criterion for 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 subspaces panned by given set of vectors; Quotient space- theorems and examples. **15 Hours**

Unit–II:Linear Transformations

Linear transformation - Definition, examples, equivalent criteria, some basic properties and 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, Eigen values and Diagonalization

Homomorphism, Isomorphism and automorphism-Examples, order of automorphism and Fundamental theorem of homomorphism; Eigen values and Eigen vectors-Computation of Eigen values, algebraic multiplicity, some basic properties of eigen values, determination of eigen vectors and eigen space and geometric multiplicity. Diagonalizability of linear transformation - Meaning, condition based on algebraic and geometric multiplicity (mentioning) and related problems (Only verification of diagonalizability). **15 Hours**

Unit–IV:Invertible Transformation and Inner product spaces

Invertible transformation - some basic properties of Invertible, singular and non-singular transformations and 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 (withproof) and related problems; Gram-Schmidt orthogonalization-Orthogonalvectors, orthonormal basis, Gram-Schmidt orthogonalization process: both proof and problems. **15 Hours**

Reference Books:

1. F.M.Stewart, *Introduction to Linear Algebra*, Dover Publications.
2. Gilbert.Strang (2015), Linear Algebra and its applications, (2ndEdition), Elsevier.
3. I. N. Herstein, *Topics in Algebra*, 2nd Edition,Wiley.
4. Kenneth Hoffman & Ray Kunze (2015), Linear Algebra, (2ndEdition), Prentice Hall India Leaning Private Limited.
5. Serge Lang (2005), Introduction to Linear Algebra (2ndEdition), SpringerIndia.
6. S.Kumaresan, *Linear Algebra*, Prentice Hall India Learning Private Limited.
7. Stephen H. Friedberg, ArnoldJ.Insel & Lawrence E.Spence (2003), Linear Algebra (4thEdition), Printice-Hall of India Pvt.Ltd.
8. T.K.Manicavasagam Pillai and K S Narayanan, Modern Algebra Volume2.
9. VivekSahai &VikasBist (2013), Linear Algebra (2ndEdition) Narosa Publishing.

MATDSCP 6.1:Practical's 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 software's.
3. Acquire knowledge of applications of Linear Algebra through FOSS.

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

Suggested Software's: Maxima/Scilab/Python/R.

SuggestedPrograms:

a. Program on linear combination of vectors.
b. Program to verify linear dependence and independence.
c. Program to find basis and dimension of the subspaces.
d. Program to verify the function is linear transformation or not.
e. Program to find the matrix of linear transformation.
f. Program to find the Eigen values and Eigen vectors of a given linear transformation.
g. Program on Rank–nullity theorem.
h. Program to verify if the given linear transformation is singular/non-singular.
i. Program to find the minimal polynomial of given transformation.
j. Program to find the algebraic multiplicity of the Eigen values of the given linear transformation.
k. Program on diagonalization

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 over all 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

i. Describe various operators arising in numerical analysis such as difference operators, shift operators and so on.
ii. Articulate the rationale behind various techniques of numerical analysis such as in finding roots,integrals and derivatives.
iii. Reproduce the existing algorithms for various tasks as mentioned previously in numerical analysis.
iv. Apply the rules of calculus and other areas of mathematics in justifying the techniques of numerical analysis.
v. Solve problems using suitable numerical technique.
vi. Appreciate the profound applicability of techniques of numerical analysis insolving real life problems and also appreciate the way the techniques are modified to improve the accuracy.

Unit–I:Algebraic and Transcendental Equations

Errors- Significant digits, absolute, relative, percentage errors, rounding off and truncation errors (meanings and related problems), general error formula (derivation of formula and problems based on it), error in series approximation: Taylor series approximations (problems only), Solutions to algebraic and transcendental equations - Bisection method, Regula-Falsi method, iterative method Newton-Raphson method and secant method (Plain discussion of the rationale behind techniques and problems on their applications). **15 Hours**

Unit–II: System of LinearAlgebraicEquations

Direct Methods– Gauss elimination method, Gauss-Jordan elimination method and Tringularization method; Iterative methods – Jacobi method, Gauss-Jacobi method, Gauss-Seidal method,Successive- Over Relaxation method(SOR) method**.** **15 Hours**

Unit–III:Polynomial Interpolations

Finite differences**.** Forward, backward and central 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, differences between them and problems on their applications). **15 Hours**

Unit-IV: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's1/3rule, Simpson's 3/8 rule and Weddell's rule (derivations for only general quadrature formula, trapezoidal rule and Simpson's $1/3^{rd}$ rule and problems on th eapplications of all formulas). **15 Hours**

Reference Books:

1. E.Isaacson and H.B.Keller, *Analysis of Numerical methods*, Dover Publications.
2. S.S. Sastry, *Introductory methods of Numerical Analysis*, 5thEdition, PHI Learning Private Limited.
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*, 4thEdition, 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:Practical's on Numerical Analysis	
Practical Hours: 4 Hours/Week	**Credits: 2**
Total Practical Hours: 60Hours	**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 Analysi studied in **MATDSCT 6.2 by** using FOSS software's.
3. Acquire knowledge of applications of Numerical Analysis through FOSS.

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

Suggested Programs:

1. Program to find root of an equation using bisection and Regula-Falsi methods.
2. Program to find root of an equation using Newton-Raphson and Secant methods.
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 solve the system of algebraic equations using SOR method
8. Program to evaluate integral using Simpson's 1/3 and 3/8 rules.
9. Program to evaluate integral using Trapezoidal and Weddle rules.
10. Program to find the sums of powers of successive natural numbers using Newton–Gregory technique.
11. Program to find differentiation at specified point using Newton-Gregory interpolation method.
12. Program to find the missing value of table using Lagrange method.