SHIVAJI UNIVERSITY, KOLHAPUR

M.Sc. (Mathematics) Entrance Examination (2025-26) Syllabus

Syllabus for Entrance Examination of M.Sc. (Mathematics) for the academic year 2025-26, will be based on B.Sc. (Mathematics) courses.

The distribution of weightage of marks will be as follows:

Sr. No.	Topic	Weightage
1	Mathematics courses of T.Y.B.Sc.(Mathematics)	80 %
2	Mathematics courses of S.Y.B.Sc.(Mathematics)	10 %
3	Mathematics courses of F.Y.B.Sc.(Mathematics)	10 %

Note that:

1. Duration of Examination : 3 hours
1. Total number of multiple choice questions (MCQs) : 100
2. Maximum Marks: 100
3. All MCQs are compulsory.

Syllabus For
B.Sc. Part -III (Mathematics)
SEMESTER V AND VI

B.Sc. (Mathematics) (Part III) (Semester – V)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2024-25

Course code : DSE – E9
Title of course : Real Analysis
Theory : 32 Hrs. (40 lecturers of 48 min.)
Marks : 50 (Credit: 02)

Course Learning Outcomes: Upon successful completion of the course students will able to:

CO 1. understand the basic facts about functions and countability of sets

CO 2. recognize bounded, convergent, divergent, Cauchy and monotonic sequences.

CO 3. calculate limit superior, limit inferior, and the limit (when exists) of a sequence..

CO 4. use different tests for convergence and absolute convergence of an infinite series of real numbers.

Unit 1: Functions and Sequence of real numbers **(20 Lect.)**

1.1. **Functions**

1.1.1. Definitions: Cartesian product, Function, domain and range of a function, inverse image and image of a set under a function, extension and restriction of functions, one - to - one (or 1 - 1) function, onto function.

1.1.2. Real-valued functions.

1.1.3. Equivalence and Countability.

1.1.4. Real numbers.

1.1.5. Least upper bounds.

1.2. **Sequence of real numbers**

1.2.1. Definition of sequence and subsequence.

1.2.2. Limit of a sequence.

1.2.3. Convergent sequence.

1.2.4. Divergent sequences.

1.2.5. Bounded sequences.

1.2.6. Monotone sequences.

1.2.7. Operations on convergent sequences.

1.2.8. Limit superior and limit inferior.

1.2.9. Cauchy sequences.

1.2.10. Summability of sequences.

Unit 2: Series of real numbers **(20 Lect.)**

2.1. Convergence and divergence.

2.2. Series with nonnegative terms.

2.3. Alternating series.

2.4. Conditional convergence and absolute convergence.

2.5. Tests for absolute convergence.

2.6. Series whose terms form nonincreasing sequence.

2.7. (C,1) summability of series.

2.8. The class ℓ^2

Recommended Books:

1. R. R. Goldberg, **Methods of Real Analysis**, Indian Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Scope of Syllabus:

Unit 1: Chapter 1: Sec.: 1.3, 1.4, 1.5, 1.6, 1.7; Chapter 2: Sec.: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11

Unit 2: Chapter 3: Sec.: 3.1, 3.2, 3.3, 3.4, 3.6, 3.7, 3.9, 3.10

Reference Books:

1. Steven G. Krantz, **Real Analysis and Foundations**, Second Edition, Chapman and Hall/CRC.
2. Shanti Narayan and M. D. Raisinghania**, Elements of Real Analysis**, Fifteenth Revised Edition, S. .Chand & Company Ltd. NewDelhi, 2014.
3. Kenneth.A.Ross, **Elementary Analysis: The Theory of Calculus**, Second Edition, Undergraduate Texts in Mathematics, Springer , 2013.
4. R.G.Bartle and D.R.Sherbert, **Introduction to Real Analysis**, Fourth Edition, Wiley India Pvt. Ltd., 2016.

B.Sc. (Mathematics) (Part III) (Semester – V)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2024-25

Course code	**:**	DSE – E10
Title of course	**:**	Modern Algebra
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO 1. learn Group structure and its properties.
CO 2. learn Ring structure and its properties.
CO 3. describe the difference between concepts Group and Ring.
CO 4. understand fundamental theorem of homomorphism, isomorphism for Group and Ring.

Unit 1: Groups **(20 Lect.)**

Groups: Definition and examples of groups, commutative group, order of a group, Quaternion group, group of residues, Definition of subgroup and examples, Definition of centre of group G ,Normalizer of an element in G, Definition of left and right cosets and congruence relation, Lagrange's Theorem, Definition of Index of H in G,Centralizer of H, Normalizer of H, Definition of cyclic group and order of element of a group, Definition of Euler's ∅ function, Euler's Theorem, Fermat's Theorem, Examples related to Euler's ∅ function and Fermat's Theorem.

Unit-2 Normal Subgroups, Homomorphism of Groups, Ring and it's properties **(20 Lect.)**

Definition and examples of subgroup, simple group , quotient group, Definition the Normalizer N(H), Definition and examples of Homomorphism, Isomorphism, epimorphism, Monomorphism, Endomorphism and Automorphism, Fundamental Theorem of group homomorphism, Second Theorem of isomorphism, Third Theorem of isomorphism, Dihedral group, Permutation group, Cayley's Theorem, Definition of Alternating group, Definition and examples of a ring, Commutative ring, Ring with unity, Definition and examples of Zero divisor, Integral Domain, Division Ring, Field, Definition and examples of Boolean ring, Definition and examples of Subring, Characteristic of a ring: Definition and examples, Definition and examples of Nilpotent, Idempotent, product of rings, Definition and examples of Ideal, Definition of Sum of two ideals and examples, Definition of Simple Ring.

RECOMMENDED BOOK

1. A Course in Abstract Algebra**,** Vijay K. Khanna, S.K.Bhambri;Vikas Publishing House Pvt.Ltd., New - Delhi – 110014, Fourth Revised Edition 2013.

SCOPE OF SYLLABUS

Unit 1: Chapter 2

Unit 2: Chapter 3 and Chapter 7

REFERENCE BOOKS:

1. Topics in Algebra,HersteinI.N.;Vikas Publishing House,1979.
2. Fundamentals of Abstract Algebra ,Malik D. S. Morderson J. N. and Sen M. K. McGraw Hill,1997.
3. A TextBook of Modern Abstract Algebra, Shanti Narayan
4. Modern Algebra, Surjeet Sing and Quazi Zameeruddin; Vikas Publishing House, 1991.
5. Lectures on Abstract Algebra, T. M. Karade, J. N. Salunkhe, K. S. Adhav, M.S.Bendre, Sonu Nilu, Einstein Foundation International, Nagpur 440022.
6. Basic AlgebraVol.I & II, N.Jacobson, W.H.Freeman 1980.
7. Algebra,Vivek Sahaiand Vikas Bist Naros Publishing House,1197.
8. A First Course in Abstract Algebra by John B. Fraleigh Pearson Education; Seventh edition (2014)

B.Sc. (Mathematics) (Part III) (Semester – V)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2024-25

Course code	**:**	DSE – E11
Title of course	**:**	**Partial Differential Equations**
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

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

CO1: understand the basic concepts of partial differential equations (PDEs) and their classification.
CO2: analyze and solve linear and some nonlinear partial differential equations using analytical methods.
CO3: apply critical thinking skills to select appropriate solution methods for different types of PDEs.
CO4: able to apply various solution techniques to solve linear partial differential equations of both first and second orders

Unit 1: An Introduction to Partial Differential Equations **(20 Lect.)**

1.1. Introduction
1.2. Order and Degree
1.3. Classification of Partial Differential Equations
1.4. Solution of Partial Differential Equations
1.5. Linear Partial Differential Equations of First Order
1.6. Derivation of Partial Differential Equation by the Elimination of arbitrary constants
1.7. Derivation of Partial Differential Equation by the Elimination of arbitrary functions
1.8. Solutions of Standard forms (non-linear equations)
1.9. Lagrange's Linear Partial Differential Equation and it's geometrical interpretation
1.10. Charpit's Method
1.11. Example on 1.2 to 1.10

Unit 2: Partial Differential Equations of Second Order **(20 Lect.)**

2.1. Introduction
2.2. Linear Homogeneous Partial Differential Equation with constant coefficients
2.3. Solution of Linear Partial Differential Equation
2.4. Rule for finding the Complementary Function (C.F.)
2.5. Method of finding Particular Integral (P.I.) of a Linear Homogeneous Partial Differential Equation
2.6. Non-homogeneous Linear Partial Differential Equation with constant coefficients
2.7. Method for finding the Complementary Function (C.F.)
2.8. Method of finding Particular Integral (P.I.) of a Non-homogeneous Linear Partial Differential Equation

Recommended Book:

1. Advanced Partial Differential Equations, Sudhir Pundir and Rimple Pundir, A Pragati Edition, Meerut (4th Edition).

Scope of Syllabus:

Unit 1: Chapter 1: Sec.: 1.1, 1.2, 1.3, 1.4, 1.5,1.6,1.7,1.8,1.9,1.12,1.14;

Unit 2: Chapter 2: Sec.: 2.1, 2.2, 2.3, 2.4, 2.5,2.6,2.7,2.8

Reference Books:

1. Differential Equations, P. P. Gupta, G. S. Malik and S. K. Mittal, A Pragati Edition, Meerut (14th Edition).
2. Differential Equations, M. L. Khanna, Jai Prakash Nath and Co., Meerut (14th Edition).
3. Theory and Problem of Differential Equations, Frank Ayres JR., Schaum Publishing CO., New York.
4. Ordinary and Partial Differential Equations, Dr. M.D. Raisinghania, S. Chand & Company Ltd., New Delhi (18th Edition)
5. An Elementary Course in Partial Differential Equations, T. Amarnath, Jones and Bartlett Publishers, Sudbary.

B.Sc. (Mathematics) (Part III) (Semester – V)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2024-25

Course code	**:**	DSE – E12
Title of course	**:**	**Integral Transform**
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

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

- **CO1**: understand meaning of Laplace Transform
- **CO2**: apply properties of LT to solve differential equations.
- **CO3**: understand relation between Laplace and Fourier Transform.
- **CO4**: understand infinite and finite Fourier Transform.

Unit: 1 Laplace and Inverse Laplace Transform. (20 Lect.)

1.1 Laplace Transform:

1.1.1 Definitions: Piecewise continuity, Function of exponential order, Function of class A and Laplace transform.

1.1.2 Existence theorem of Laplace transform.

1.1.3 Laplace transform of standard functions.

1.1.4 First shifting theorem, Second shifting theorem and Change of scale property.

1.1.5 Laplace transform of derivatives, Laplace transform of integrals.

1.1.6 Effect of Multiplication, Effect of division.

1.1.7 Laplace transform of periodic functions.

1.1.8 Laplace transform of Heaviside's unit step function and Dirac delta function.

1.1.9 Examples based on 1.1.1 to 1.1.8

1.2 Inverse Laplace Transform:

1.2.1 Inverse Laplace transform.

1.2.2 Standard results of inverse Laplace transform.

1.2.3 First shifting theorem, Second shifting theorem and Change of scale property.

1.2.4 Inverse Laplace transform of derivatives, inverse Laplace transform of integrals.

1.2.5 The Convolution theorem.

1.2.6 Effect of multiplication and division.

1.2.7 Inverse Laplace by partial fractions.

1.2.8 Examples based on 1.2.1 to 1.2.7

Unit 2 Fourier Transform (20 Lect.)

2.1.1 Infinite Fourier transform.

2.1.2 Infinite Fourier sine and cosine transform.

2.1.3 Infinite inverse Fourier sine and cosine transform.

2.1.4 Relationship between Fourier transform and Laplace transform.

2.1.5 Change of Scale Property, Modulation theorem.

2.1.6 The Derivative theorem, Extension theorem.

2.1.7 Convolution theorem.

2.1.8 Finite Fourier sine and cosine transform.

2.1.9 Finite inverse Fourier sine and cosine transform.

2.1.10 Examples based on 2.1.1 to 2.1.9.

Recommended Books:

1. J. K.Goyal, K.P.Gupta, Laplace and Fourier Transform, A Pragati Prakashan, Meerut, 2016.

Scope of Syllabus:

Unit 1: Part I: 1.0 to 1.6, Part II: 1.0 to 1.3.

Unit 2: Part I: 2.0 to 2.3, Part II: 2.0 to 2.1.

Reference Books:

1. Dr. S. Sreenadh, Fourier series and Integral Transform, S.Chand, New Delhi, 2021
2. B.Davies, Integral Transforms and Their Applications, Springer Science, 2017.
3. Murray R. Spiegel, Laplace Transforms, Schaum’s outlines , 2018.

B.Sc. (Mathematics) (Part III) (Semester – VI)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2024-25

Course code	:	DSE – F9
Title of course	:	**Metric Spaces**
Theory	:	32 Hrs. (40 lecturers of 48 min.)
Marks	:	50 (Credit: 02)

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

CO1: acquire the knowledge of notion of metric space, open sets and closed sets.

CO2: demonstrate the properties of continuous functions on metric spaces,

CO3: apply the notion of metric space to continuous functions on metric spaces.

CO4: understand the basic concepts of connectedness, completeness and compactness of metric spaces,

Unit –1 Limits and Continuous Functions on Metric Spaces **(20 Lect.)**

Limit of a function on the real line (Revision), Metric Spaces, Limits in Metric Spaces, Functions continuous at a point on the real line, Reformulation, Functions continuous on a metric space, Open Sets, Closed Sets, More about open sets.

Unit 2: Connectedness, Completeness and Compactness **(20 Lect.)**

Connected Sets, Bounded sets and totally bounded sets, Complete metric spaces, Compact metric spaces, Continuous functions on compact metric spaces.

Recommended Book:

1. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH Publishing House.(2017).

Scope of Syllabus:

Unit 1: Chapter-4:4.1, 4.2,4.3; Chapter-5: 5.1,5.2,5.3,5.4,5.5; Chapter-6:6.1

Unit 2: Chapter-6:6.2,6.3,6.4,6.5,6.6

Reference Books:

1. T. M. Apostol, Mathematical Analysis,Narosa Publishing House.(2002)
2. Satish Shirali, H. L. Vasudeva, Mathematical Analysis,Narosa Publishing House.(2013)
3. D. Somasundaram, B. Choudhary, First Course in Mathematical Analysis, Narosa Publishing House,(2018).
4. W. Rudin, Principles of Mathematical Analysis,McGraw Hill BookCompany(1976).
5. Shantinarayan, Mittal, A Course of Mathematical Analysis,S.Chand and Company(2013).
6. J.N. Sharma, Mathematical Analysis-I, Krishna PrakashanMandir, Meerut.(2014)
7. S.C.Malik, Savita Arora,Mathematical Analysis,New age International Ltd(2005).

B.Sc. (Mathematics) (Part III) (Semester – VI)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2024-25

Course code	:	DSE – F10
Title of course	:	**Linear Algebra**
Theory	:	32 Hrs. (40 lecturers of 48 min.)
Marks	:	50 (Credit: 02)

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

CO1: understand the fundamental concepts in linear algebra, enabling them to analyze and manipulate vector spaces, linear transformations.

CO2: relate matrices and linear transformations

CO3: acquire skills to perform computations related to inner product and orthogonalization techniques.

CO4: compute Eigen values and Eigen vectors of a linear transformations.

Unit 1: Vector Spaces and Linear Transformations (20 Lect.)

Vector space, Subspace**,** Sum of subspaces, direct sum, Quotient space, Homomorphism or Linear transformation, Kernel and Range of homomorphism, Fundamental Theorem of homomorphism, Isomorphism theorems, Linear Span, Finite dimensional vector space, Linear dependence and independence, basis, dimension of vector space and subspaces.

One-one and onto Linear Transformations, rank and nullity of a linear transformation, Sylvester's Law, Algebra of Linear Transformations - Sum and scalar multiple of Linear Transformation, The vector space Hom $(V,\ W)$, Product (composition) of Linear Transformations, Linear operator, Linear functional, Invertible and non-singular Linear Transformation, Matrix of Linear Transformation and its examples.

Unit 2: Inner Product Spaces, Eigen values and Eigen vectors (20 Lect.)

Inner product space, norm of a vector, Cauchy- Schwarz inequality, Orthogonality, Generalized Pythagoras Theorem, orthonormal set, Gram-Schmidt orthogonalisation process,

Eigen values and Eigen vectors, Eigen space, Characteristic Polynomial of a matrix and remarks on it, similar matrices, Characteristic Polynomial of a Linear operator, Examples on eigen values and eigen vectors of matrices, Cayley Hamilton theorem (without proof), Applications of Cayley Hamilton theorem (Examples).

RECOMMENDED BOOKS

1. Khanna V. K. and Bhambri S. K., **A Course in Abstract Algebra,** Vikas Publishing House PVT Ltd., New Delhi, 2016, 5th edition,
   [Scope: Chaper-10,11,12 & 13]
2. Grewal, B.S., **Higher Engineering Mathematics**, 42nd Edition, Khanna Publishers, New Delhi, 2012. **[Scope: Chaper-2: Art. 2.15]**

REFERENCE BOOKS

1. **Elementary Linear Algebra** (with Supplemental Applications), H. Anton & C. Rorres; 11th Edition, Wiley India Pvt. Ltd (Wiley Student Edition), New Delhi, 2016.
2. **Linear Algebra**, S. Friedberg, A. Insel, L. Spence; 4th Edition, Prentice Hall of India, 2014.
3. **Linear Algebra,** Holfman K. and Kunze R.; Prentice Hall of India, 1978.
4. **Linear Algebra,** Lipschutz' S; Schaum's Outline Series, McGraw Hill, Singapore, 1981.

Course code	:	DSE – F11
Title of course	:	**Complex Analysis**
Theory	:	32 Hrs. (40 lecturers of 48 min.)
Marks	:	50 (Credit: 02)

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

CO1: understand the fundamental concepts in linear algebra, enabling them to analyze and manipulate vector spaces, linear transformations.

CO2: relate matrices and linear transformations

CO3: acquire skills to perform computations related to inner product and orthogonalization techniques.

CO4: compute Eigen values and Eigen vectors of a linear transformations.

Unit 1: Analytic Functions and Integrals **(20 Lect.)**

1.1 Complex numbers: Sum and products, Basic algebraic properties of complex numbers , Further properties, Vectors and Moduli, Complex conjugates, Exponential form, Regions in the complex plane.

1.2 Analytic functions: Function of complex variable, Limits, Theorems on limits (Theorems without proof), Continuity (Theorems without proof), Derivatives, Differentiation formulas, Cauchy-Riemann equations, Sufficient conditions for differentiability, Polar Coordinates: Derivation of Cauchy-Riemann equations in polar form and examples, Analytic functions (Theorem without proof), Examples, Harmonic functions.

1.3 Integrals: Derivative of functions w(t), Definite integrals of functions, Contours, Contour integrals, Some examples, Cauchy-Goursat theorem (Theorem without proof), Simply connected domains, Multiply connected domains, Cauchy Integral formula, An extension of the Cauchy Integral formula, Some consequences of the extension, Liouville's theorem and The fundamental theorem of algebra.

Unit 2: Sequences, Series and Residue Calculus **(20 Lect.)**

2.1 Convergence of sequence, Convergence of series, Taylor series (Theorem without proof), Examples on Taylors and Maclaurin's series, Laurent's Theorem (Theorem without proof), Examples on Laurent's series.

2.2 Residues and Poles : Isolated singular points, Residues, Cauchy Residue theorem, Residue at infinity, The three type of isolated singular points, Residue at poles, Examples, Zeros of analytic functions, Zeros and poles.

2.3 Application of residues : Evaluation of improper integrals, Examples, Definite integrals involving sines and cosines.

Recommended book:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill Education (India) Edition, 2014. Eleventh reprint 2018.

Scope of Syllabus:

Unit 1: Chapter1 : 1, 2, 3, 4, 5, 6, 11, Chapter 2 : 12, 15,16, 18, 19, 20, 21, 22, 23, 24, 25, 26, Chapter 4: 37, 38, 39, 40, 41, 46, 48, 49, 50, 51, 52, 53.

Unit II: Chapter 5: 55, 56, 57, 59, 60, 62. Chapter 6: 68, 69, 70, 71, 72, 73, 74, 75, 76, Chapter 7: 78, 79, 85.

Reference books:

1. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, Second Edition , 2005, Ninth reprint 2013.
2. Lars V Ahlfors, Complex Analysis, McGraw-Hill Education; 3 edition (January 1, 1979).
3. S. B. Joshi, T. Bulboaca and P. Goswamy, Complex Analysis, Theory and Applications, DeGruyter, Germany(2019).
4. Shanti Narayan, Dr. P. K. Mittal, Theory of functions of a complex variable, S. Chand, second edition, 2005.

B.Sc. (Mathematics) (Part III) (Semester – VI)

Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)

Syllabus to be implemented from Academic Year 2024-25

Course code	**:**	DSE – F12
Title of course	**:**	**Operations Research**
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

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

CO1: define and explain the fundamental concepts of Operations Research.

CO2: identify and develop operations research model describing a real-life problem.

CO3: understand the mathematical tools that are needed to solve various optimization problems.

CO4: solve various linear programming, transportation, assignment problems related to real life.

Unit 1: Linear Programming (LP) **(20 Lect.)**

1.1 Operations Research: Origin, Definition and scope.
1.2 Linear Programming: Introduction
1.3 Linear Programming Formulation: Examples
1.4 General Formulation of Linear Programming Problem
1.5 Some Important Definitions: Solution to linear programming problem, feasible solution, Basic feasible solution, Optimum basic feasible solution, unbounded solution
1.6 Graphical solution of LP Problems
1.7 Simplex method for LP Problems
1.8 Problems based on 1.7
1.9 Artificial Variable Techniques: Two Phase Method. Big M Method
1.10 Problems based on 1.9

Unit 2: Assignment Problem and Transportation problem **(20 Lect.)**

2.1 **Transportation Problem**: Introduction
2.2 Mathematical Formulation of the Transportation Problem
2.3 Definitions: Feasible Solution, Basic Feasible Solution, Optimal Solution
2.4 Theorem (Existence of Feasible Solution): Statement and Proof
2.5 Methods for Initial Basic Feasible Solution: North – West Corner Rule (NWCR), Lowest Cost Entry (Matrix Minima) Method (LCM), Vogel's Approximation Method (VAM) (Unit Cost Penalty Method)
2.6 Problems based on 2.5
2.7 Definition: Non – degenerate solution of Transportation Problem
2.8 Optimality Test: MODI Method.
2.9 Problems based on 2.8
2.10 Unbalanced Transportation Problem
2.11 Problems based on 2.10
2.12 **Assignment Problem:** Introduction
2.13 Mathematical Formulation of the Assignment Problem
2.14 Reduction Theorem: Statement and Proof
2.15 Method for solving the Assignment Problem: Hungarian Assignment Method
2.16 Problems based on 2.15

2.17 Maximization Case in Assignment Problem
2.18 Unbalanced Assignment Problem
2.19 Travelling Salesman Problem
2.20 Problems based on 2.17 to 2.19

Recommended Book: S. D. Sharma, Operations Research - Theory Methods and Applications" Kedar Nath, Ram Nath Meerut, Delhi Reprint 2019.

Reference Books:

1. J. K. Sharma: Operations Research Theory and Applications, Mac Millan Co.
2. J. K. Sharma: Mathematical Model in Operation Research, Tata McGraw Hill
3. R. K. Gupta: Operations Research, Krishna Prakashan Mandir, Meerut.
4. Hamady Taha: Operations Research: Mac Millan Co.
5. P.Rama Murthy: Operations Research, New Age International (P) Limited, Publishers.

Syllabus For
B.Sc. Part -II (Mathematics)
SEMESTER III AND IV

Course code : DSC – C5
Title of course : Elements of Differential Equations
Theory : 32 Hrs. (40 lecturers of 48 min.)
Marks : 50 (Credit: 02)

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

CO1: identify types of higher order ordinary differential equations.
CO2: solve different types of higher order ordinary differential equations.
CO3: understand geometrical interpretation of simultaneous and total differential equations.

Unit 1: **(20 Hrs.)**

1.1. **Homogeneous linear differential equations**
  1.1.1. Definition: Homogeneous linear differential equation (Cauchy - Euler differential equation).
  1.1.2. Method of solution and examples.
  1.1.3. Definition: Legendre's linear differential equation.
  1.1.4. Method of solution of Legendre's linear differential equation and examples.

1.2. **Second order linear differential equations**
  1.2.1. Definition (general form): Second order linear differential equation.
  1.2.2. Methods of solution of Second order linear differential equation.
    1.2.2.1. Complete solution when one integral is known: method and examples.
    1.2.2.2. Transformation of the equation by changing the dependent variable (removal of first order derivative) and examples.
    1.2.2.3. Transformation of the equation by changing the independent variable and examples.
    1.2.2.4. Method of variation of parameters and examples.

Unit 2: **(12 Hrs.)**

2.1. Ordinary Simultaneous linear differential equations
  2.1.1. Definition: Ordinary Simultaneous linear differential equations.
  2.1.2. Geometrical interpretation of ordinary simultaneous differential equations.
  2.1.3. Methods of Solving Simultaneous Linear Differential Equations and examples.

2.2. Total differential equations.
  2.2.1. Definition: Total differential equation.
  2.2.2. Necessary condition for integrability of total differential equation
  2.2.3. Geometrical interpretation of total differential equation. Geometrical relation between total differential equations and simultaneous Linear differential equations
  2.2.4. Methods of solving total differential equations:
    a) Method of Inspection.
    b) Solution of homogeneous equations.

c) Use of Auxiliary equation.
d) Treating one variable as a constant.

Recommended book:

1. Ordinary and Partial Differential Equations, M. D. Raisinghania, Eighteenth revised edition 2016; S. Chand and Company Pvt. Ltd. New Delhi.

Scope:

[**Part I – Chapter 6:** 6.1, 6.2, 6.3, 6.4, 6.9, 6.10, 6.11;

Part I – Chapter 10: 10.1, 10.2, .10.3, 10.4 (excluding 10.4A and 10.4B), 10.5, 10.6, 10.7, 10.8, 10.9, 10.10, 10.11, 10.13, 10.14;

Part II – Chapter 2: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11;

Part II – Chapter 3: 3.1, 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13]

Reference books:

1. Differential Equations, Shepley L. Ross, Third Edition 1984; John Wiley and Sons, New York.
2. Elements of Partial Differential Equations, Ian Sneddon, Seventeenth Edition, 1982; Mc-Graw-Hill International Book Company, Auckland
3. Introductory course in Differential Equations, D. A. Murray, Khosala Publishing House, Delhi.

Course code	**:**	DSE – C6
Title of course	**:**	Numerical Methods
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

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

CO1: find numerical solutions of algebraic, transcendental and system of linear equations.

CO2: learn about various interpolating methods to find numerical solutions.

CO3: find numerical solutions of integration and ODE by using various methods.

CO4: apply various numerical methods in real life problems.

Unit- 1 **(16Hrs.)**

1.1 Solutions of Algebraic and Transcendental Equations:

1.1.1 Introduction
1.1.2.Mathematical Preliminaries
1.1.3 Bisection Method
1.1.4 Method of False position
1.1.5 Newton- Raphson method
1.1.6 Examples based on art.1.1.3 to 1.1.5

1.2 Interpolation

1.2.1 Introduction
1.2.2 Finite differences
1.2.3 Forward differences
1.2.4 Backward differences
1.2.5 Symbolic relations and Separation of symbols
1.2.6 Newton’s formulae for Interpolation
  1.2.6.1 Newton’s forward difference interpolation formula
  1.2.6.2 Newton’s backward difference interpolation formula
1.2.7 Interpolation with Unevenly Spaced Points
  1.2.7.1 Lagrange’s Interpolation Formula
1.2.8 Examples based on art.1.2.2 to 1.2.7

Unit- 2 **(16Hrs.)**

2.1 Numerical Integration

2.1.1 General formula
2.1.2 Trapezoidal rule
2.1.3 Simpson's 1/3- rule
2.1.4 Simpson's 3/8- rule
2.1.5 Examples based on art. 2.1.2 to 2.1.4.

2.2 Solutions of Linear system of equations

2.2.1 Solutions of linear system - Direct method
  2.2.1.1 Gauss Elimination Method
2.2.2 Solutions of linear system - Iterative method
  2.2.2.1 Gauss-Seidel Method
2.2.3 Examples based on art. 2.2.1 to 2.2.2.

2.3 Numerical Solutions of ODE:

2.3.1 Introduction
2.3.2 Solution by Taylor's series method
2.3.3 Picard's method of successive approximation
2.3.4 Euler's method
2.3.5 Modified Euler's method
2.3.6 Runge-Kutta methods
  2.3.6.1 second order Runge-Kutta (without proof)
  2.3.6.2 fourth order Runge-Kutta (without proof)
2.3.7 Examples based on art. 2.3.2 to 2.3.6.

Recommended Book -

1. S. S. Sastry - Introductory Methods of Numerical Analysis: Fifth Edition, Prentice Hall India Learning Private Limited, New Delhi (2012).

Scope: [**Chapter-1:** 1.1(a,b,d,c,f), 1.2**; Chapter-2:** 2.1, 2.2, .2.3, 2.5; **Chapter-3:** 3.1, 3.3, 3.6, 3.9; **Chapter-6:** 6.4; **Chapter-7:** 7.5, 7.6; **Chapter-8:** 8.1, 8.2, 8.3, 8.4, 8.5]

Reference Books -

1. M.K.Jain, S.R.K.Iyengar & R.K.Jain - Numerical Methods (Problems and Solutions): Revised Second Edition, New Age International Pvt Ltd Publishers, Mumbai.
2. H.C. Saxena - Finite Differences and Numerical Analysis, S. Chand & Company Ltd.(2005).
3. Dr. B. S. Grewal, Numerical Methods in Engineering & Science, Khanna Publishers.

B.Sc. (Mathematics) (Part II) (Semester – IV)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)

Course code	**:**	DSE – D5
Title of course	**:**	Vector Calculus
Theory	**:**	32 Hrs. (40 lecturers of 48 min.)
Marks	**:**	50 (Credit: 02)

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

CO1**:** understand and evaluate the concepts of gradient, divergence and curl of point functions in terms of cartesian co-ordinate system.

CO2**:** understand and evaluate different types of line, surface & volume integrals and the two integral transformation theorems of Gauss and Stokes.

Unit 1 Differential Operators (16 Hrs.)

1.1 Scalar and Vector valued Point functions
1.2 Limit and continuity of a scalar and vector point functions
1.3 Directional Derivatives of scalar and vector Point Functions & examples
1.4 The Operator ∇
1.5 Gradient of a Scalar Point Function & examples
1.6 Geometrical Interpretation of grad $\emptyset$, where $\emptyset$ is a scalar point function
1.7 Divergence and Curl of vector point function
1.7.1 Definition of $div\ f$ and $curl\ f$, where f is a vector point function
1.7.2 Expressions of $div\ f$ and $curl\ f$ in terms of components of f
1.7.3 Characters of div f and curl f as point functions
1.7.4 Problems based on 1.7
1.8 Gradient, Divergence and Curl of Sums
1.8.1 $grad\ (\emptyset \pm \varphi) = grad\ \emptyset \pm grad\ \varphi$
1.8.2 $div\ (f \pm g) = div\ f \pm div\ g$
1.8.3 $curl\ (f \pm g) = curl\ f \pm curl\ g$
1.9 Gradient, Divergence and Curl of Products
1.9.1 $grad\ (\emptyset\varphi),\ grad\ (f \cdot g)$
1.9.2 $div\ (\emptyset f),\ div\ (f \times g)$
1.9.3 $curl\ (\emptyset f),\ curl\ (f \times g)$
1.10 Second Order Differential Operators
1.10.1 $div\ grad\ \emptyset = \nabla \cdot \nabla\emptyset = \frac{\partial^2\emptyset}{\partial x^2} + \frac{\partial^2\emptyset}{\partial y^2} + \frac{\partial^2\emptyset}{\partial z^2}$
1.10.2 $curl\ grad\ \emptyset = \nabla \times \nabla\emptyset = 0$
1.10.3 $div\ curl\ f = \nabla \cdot \nabla \times f = 0$
1.10.4 $grad\ div\ f = curl\ curl\ f + \sum \frac{\partial^2 f}{\partial x^2}$
1.11 The Laplacian Operator, ∇^2 and examples

Unit 2 Integral Transformations (16 Hrs.)

2.1 Some preliminary concepts: Oriented curve, Smooth curve, Smooth surface, classification of regions

2.2 Line integrals

2.3 Circulation, work done by a force

2.4 Surface integrals, flux

2.5 Volume integrals

2.6 Problems based on 2.2 to 2.5

2.7 Green's theorem in the plane

2.8 Green's theorem in the plane in vector notation

2.9 Problems based on 2.7 and 2.8

2.10 The Divergence theorem of Gauss (statement only)

2.11 Stoke's theorem (statement only)

2.12 Line integrals independent of path

2.13 Physical interpretation of div. and curl

Recommended Book:

1. Shanti Narayan & P. K. Mittal: Vector Calculus, S. CHAND & CO (Pvt) LTD, RAM NAGAR, NEW DELHI-110055.

Scope: [**Chapter -6:** 6.1 to 6.17]

2. J. N. Sharma & A. R. Vasishtha: Vector Calculus, KRISHNA Prakashan Media (P) Ltd., Meerut.

Scope: [Chapter- 3]

Reference Books:

1. M. L. Khanna: Vector Calculus, Jai Prakash Nath & Co. Meerut
2. P. N. Wartikar and J. N. Wartikar: A text book of Applied Mathematics (Vol-II), Vidhyarthi Griha Prakashan, Pune.
3. B. S. Grewal: Higher Engineering Mathematics, Khanna Publishers, New Delhi-110002.
4. R. K. Jain & S. R. K. Iyengar: Advanced Engineering Mathematics, fourth edition, Narosa Publishing House New Delhi.

Course code : DSE – D6
Title of course : Integral Calculus
Theory : 32 Hrs. (40 lecturers of 48 min.)
Marks : 50 (Credit: 02)

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

CO1: understand special functions.
CO 2: understand types of multiple integrals.
CO 3: apply special functions in applications.
CO 4: apply multiple integrals in real life problems.

Unit 1. Gamma and Beta Function. **(16Hrs.)**

1.1 Gamma function.

1.1.1 Definition of Gamma function and examples.
1.1.2 Properties of Gamma function.

1.1.2.1 $\Gamma(1) = 1$

1.1.2.2 $\Gamma(n+1) = n\,\Gamma(n)$ in general.

1.1.2.3 $\Gamma(n+1) = n!$ if n is positive integer.

1.1.2.4 $\Gamma(0) = \infty$, $\Gamma(\infty) = \infty$

1.1.2.5 $\Gamma(n) = 2\int_0^\infty e^{-x^2} x^{2n-1} dx$, $n > 0$

1.1.2.6 $\Gamma(n) = k^n \int_0^\infty e^{-kx} x^{n-1} dx$, $n, k > 0$

1.1.2.7 Examples based on article 1.1.2

1.2 Beta function.

1.2.1 Definition of Beta function and examples.
1.2.2 Properties of Beta function.

1.2.2.1 $\beta(m,n) = \beta(n,m)$; $m,n \geq 0$

1.2.2.2 $\beta(m,n) = 2\int_0^{\frac{\pi}{2}} sin^{2m-1}\theta cos^{2n-1}\theta\, d\theta$; $m,n \geq 0$

1.2.2.3 $\int_0^{\frac{\pi}{2}} sin^p\theta\, cos^q\theta\, d\theta = \frac{1}{2}\beta\left(\frac{p+1}{2}, \frac{q+1}{2}\right)$ p, q > -1

1.2.2.4 $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$, m, n > 0

1.2.2.5 $\Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$

1.2.2.6 $\beta(m,n) = \int_0^\infty \frac{x^{m-1}}{(1+x)^{m+n}} dx$

1.2.2.7 $\beta(m,n) = a^n b^m \int_0^\infty \frac{x^{m-1}}{(a+bx)^{m+n}} dx$

1.2.2.8 Duplication formula of Gamma function.

1.2.2.9 Examples based on article 1.2.2

Unit 2. Differentiation under integral sign, Error functions and Multiple integrals (16Hrs.)

2.1 Differentiation under integral sign

2.1.1 Leibnitz first rule of differentiation under integral sign**.**

2.1.2 Leibnitz second rule of differentiation under integral sign**.**

2.1.3 Examples based on articles 2.1.1 and 2.1.2

2.2 Error functions

2.2.1 Definition of $\mathrm{erf}(x)$, $\mathrm{erf_c}(x)$ and examples.

2.2.2 Properties of error functions.

2.2.2.1 $\mathrm{erf}(0) = 0,\ \mathrm{erf}(\infty) = 1$

2.2.2.2 $\mathrm{erf}(x) + \mathrm{erf_c}(x) = 1$

2.2.2.3 $\mathrm{erf}(-x) = -\mathrm{erf}(x)$

2.2.2.4 $\mathrm{erf_c}(-x) = 1 + \mathrm{erf}(x)$

2.2.2.5 $\mathrm{erf_c}(x) + \mathrm{erf_c}(-x) = 2$

2.2.2.6 Examples based on article 2.2.2

2.3 Multiple Integrals

2.3.1 Evaluation of double integrals in Cartesian form.

2.3.2 Evaluation of double integrals in Polar form.

2.3.3 Evaluation of double integrals in Cartesian form over the given region.

2.3.4 Evaluation of double integrals in Cartesian form by changing order of integration.

2.3.5 Evaluation of double integrals from Cartesian form to Polar form.

2.3.6 Proof of 1.2.2.4

Recommended Book:

1. P. N. Wartikar and J. N. Wartikar, A text book of Applied Mathematics,
Pune Vidhyarthi Griha Prakashan, Pune. Vol. I, 2011.

Scope: Section III: Integral Calculus: Chapter XIV: 14.9,
Chapter XVI: 16.1 to 16.4, Chapter XIX: 19.1 to 19.3, Chapter XXI: 21.1 to 21.5

Reference Books:

1. Shantinarayan and Dr. P. K. Mittal, Integral Calculus, S. Chand and Company, New Delhi, 2020.
2. B. S. Grewal, Higher Engineering Mathematics, Khanna Publishers, Delhi, 2012.

Syllabus For
B.Sc. Part -I (Mathematics)
SEMESTER I AND II

B.Sc. (Mathematics) (Part I) (Semester – I)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2022-23

Course code:	**DSC – A5**
Title of course:	**Calculus**
Theory:	**32 Hrs. (40 lecturers)**
Marks:	**50 (Credit: 02)**

Course Learning Outcomes: Upon successful completion of the course students will able to:
1. Evaluate the limit and examine the continuity of a function at a point.
2. Understand the consequences of mean value theorems for differentiable functions.
3. Apply Leibnitz theorem to obtain higher derivatives of product of two differentiable functions.

Unit – 1: Limit, Continuity and Differentiability **(20 lect.)**

1.1 Limits: ε – δ definition, infinite limit ($f \to \infty$ as $x \to c$), limit at infinity ($f \to l$ as $x \to \infty$ and $f \to \infty$ as $x \to \infty$) .

1.2 Left hand and Right hand limits: definition and examples.

1.3 Properties of limits:

Theorem: If f and g are two functions defined on some neighbourhood of c such that $\lim_{x \to c} f(x) = l$, $\lim_{x \to c} g(x) = m$ then

(i) $\lim_{x \to c}(f + g)(x) = l + m$

(ii) $\lim_{x \to c}(f - g)(x) = l - m$

(iii) $\lim_{x \to c}(f \cdot g)(x) = lm$

(iv) $\lim_{x \to c}(f/g)(x) = l/m \ \ if \ m \neq 0$ (without proof)

1.4 Evaluation of limit: Examples (using techniques like factorization, rationalization, Left hand and Right hand limits etc.).

1.5 Continuous functions: definition of Continuity at a point, definition of continuity in an interval.

1.6 Properties of continuous functions:

1.6.1 Theorem: Let f and g be two functions continuous at a point c, then the functions $f + g$, $f - g$, fg are also continuous at c and if $g(c) \neq 0$, then f/g is also continuous at c.

Functions continuous on closed intervals:

1.6.2 Definition of bounded function

1.6.3 Theorem (Statement only): If a function f is continuous in a closed interval, then it is bounded therein.

1.6.4 Theorem: If a function f is continuous on a closed interval $[a,\ b]$, then it attains its bounds at least once in $[a,\ b]$.

1.6.5 Theorem: If a function f is continuous at an interior point c of an interval $[a,\ b]$ and $f(c) \neq 0$, then $\exists$ a $\delta > 0$ such that $f(x)$ has the same sign as $f(c)$, for every $x \in\ ]c-\delta,\ c+\delta[$.

1.6.6 Corollary (Statement only): If f is continuous at the end point b of $[a,\ b]$ and $f(b) \neq 0$, then there exists an interval $]b-\delta,\ b[$ such that $f(x)$ has the sign of $f(b)$ for all x in $]b-\delta,\ b]$.

1.6.7 Corollary (Statement only): If f is continuous at the end point a of $[a,\ b]$ and $f(a) \neq 0$, then there exists an interval $[a,\ a+\delta[$ such that $f(x)$ has the sign of $f(a)$ for all x in $[a,\ a+\delta[$.

1.6.8 Theorem: If a function f is continuous on a closed interval $[a,\ b]$ and $f(a)$ and $f(b)$ are of opposite signs ($f(a) \cdot f(b) < 0$), then there exists at least one point $\alpha \in\ ]a,\ b[$ such that $f(\alpha) = 0$.

1.6.9 Intermediate Value Theorem.

1.6.10 Corollary (Statement only): A function f, which is continuous on a closed interval $[a, b]$, assumes every value between its bounds.

1.7 Discontinuous functions: Definition, Types of discontinuities – (i) removable discontinuity (ii) discontinuity of first kind (iii) discontinuity of second kind.

1.8 Examples on 1.5 and 1.7

1.9 Uniform continuity: definition and simple examples

1.10 Theorem: A function which is uniformly continuous on an interval is continuous on that interval.

1.11 Differentiability at a point and Differentiability in an interval: definitions.

1.12 Examples on 1.11

1.13 (Differentiability and continuity) Theorem: A function which is derivable at a point is necessarily continuous at that point

Unit – 2: Mean Value Theorems, Successive Differentiation, Expansions of functions

(20 lect.)

2.1 Mean Value Theorems

2.1.1 Rolle's Mean Value Theorem, Geometrical interpretation.

2.1.2 Lagrange's Mean Value Theorem, Geometrical interpretation.

2.1.3 Cauchy's Mean Value Theorem.

2.1.4 Examples on 2.1.1, 2.1.2, 2.1.3.

2.2 Successive Differentiation

2.2.1 Higher order derivatives: notations.

2.2.2 Calculation of n^{th} derivative: Standard results

$(ax+b)^m$, $1/(ax+b)$, $\log(ax+b)$, a^{mx}, e^{mx}, $\sin(ax+b)$, $\cos(ax+b)$, $e^{ax}\sin(bx+c)$, $e^{ax}\cos(bx+c)$.

2.2.3 Determination of n^{th} derivative: examples.

2.2.4 Leibnitz's Theorem.

2.2.5 Examples on 2.2.4.

2.3 Expansion of functions

2.3.1 Maclaurin's theorem (Statement only), examples using Maclaurin's theorem.

2.3.2 Taylor's theorems (Statement only), examples using Taylor's theorem.

Recommended Books:

1. **Mathematical Analysis**, S. C. Malik and Savita Arora, New Age International Publishers, 4^{th} Edition (2012) – For Unit 1
2. **Differential Calculus,** Shanti Narayan and P.K. Mittal, S. Chand publishing, 15^{th} edition (2016) – For Unit 2.

Reference Books:

1. **Differential Calculus**, Gorakh Prasad, Pothishala Pvt. Ltd., 19th edition (2016).
2. **Aspects of Calculus**, Gabriel Klambauer, Springer-Verlag.(1986)
3. **Calculus with Maple Labs**, Wieslaw Krawcewicz & Bindhyachal Rai, Narosa (2003).
4. **Calculus**, George B. Thomas Jr., Joel Hass, Christopher Heil & Maurice D. Weir Pearson Education, 14th edition (2018).

B.Sc. (Mathematics) (Part I) (Semester – I)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2022-23

Course code: **DSC – A6**
Title of course: **Differential Equations**
Theory: **32 Hrs. (40 lecturers)**
Marks: **50 (Credit: 02)**

Course Learning Outcomes: Upon successful completion of the course students will able to:
1. Understand types of differential equations.
2. Solve different types of ordinary differential equations.
3. Understand applications of differential equations.

Unit – 1: Ordinary differential equations of first order and first degree (22 lect.)

Definition, Order and Degree, Exact differential equations, Necessary and sufficient condition for exactness, Differential equations reducible to exact, Integrating factors with rules, Linear differential equations, Differential equations reducible to linear differential equation, Bernoulli's differential equations.

Orthogonal trajectories, orthogonal trajectories to Cartesian and polar curves. Differential equations of first order but not of first degree: Equations that can be factorized, Equations solvable for p, Equations that cannot be factorized, Equations solvable for x, Equations solvable for y and Clairaut's form.

Unit – 2: Linear differential equations with constant coefficients (18 lect.)

Definition, General solution, Auxiliary equation, Complementary function, Types of complementary function: real and distinct roots, real and repeated roots , complex roots, complex and repeated roots, mixed roots, Examples on different types of complementary function, Particular integral, Particular integrals of the functions: e^{ax}, sin ax, cos ax, x^m, $e^{ax} V$, x.V and general method.

Recommended Books:

1. **Ordinary and partial differential equations**, M. D. Raisinghania, S. Chand and Company Pvt. Ltd, New Delhi, 18th Revised Edition (2016).

Reference Books:

1. **Introductory course in differential equations**, D. A. Murray, Khosala Publishing House, Delhi.
2. **An Introduction to Differential Equations**, R. K. Ghosh and K. C. Maity. Book and Allied (P) Ltd., Seventh Edition (2000).
3. **Differential Equations and Their Applications**, Zafar Ahasan, PHI, Second Edition (2004).

B.Sc. (Mathematics) (Part I) (Semester – II)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2022-23

Course code: **DSC – B5**
Title of course: **Multivariable Calculus**
Theory: **32 Hrs. (40 lecturers)**
Marks: **50 (Credit: 02)**

Course Learning Outcomes: Upon successful completion of the course students will able to:

1. Learn conceptual variations while advancing from one variable to several variables in calculus.
2. Set up and solve optimization problems involving several variables.
3. Learn the concept of Jacobian of a transformation.

Unit – 1: Partial differentiation **(20 lect.)**

Functions of two variables: domain, Neighbourhood of a point, Continuity of functions of two variables (at a point), Limit of functions of two variables, Partial derivatives: first order partial derivatives, partial derivatives of higher order, Geometrical interpretation of partial derivatives, examples,

Homogeneous functions: definition, Euler's theorem on homogeneous functions (Case of two and three variables), examples using Euler's theorem. Total Differentials, Differentiation of composite functions, examples, Implicit function: first and second order derivative of implicit functions and its examples. Taylor's theorem for a function of two variables, its examples.

Unit – 2: Extreme values and Jacobian **(20 lect.)**

Maxima and minima of functions of two variables: Condition for existence of maxima or minima, stationary and extreme points, Sign of quadratic expression, Lagrange's condition for maximum and minimum values of a function of two variables, examples, Lagrange's method of undetermined multipliers, examples using Lagrange's method.

Jacobian: Definition, examples. Jacobian of function of function (for the case of two and three variables and proof of the corollary $J.J' = 1$ is expected), Jacobian of implicit functions, examples using these properties.

Recommended Books:

1. **Differential Calculus**, Shanti Narayan and P.K. Mittal, S. Chand publishing, 15^{th} edition (2016).

Reference Books:

1. **Basic Multivariable Calculus**, J. E. Marsden , A. J Tromba & A. Weinstein; Springer Verlag, New New York, 1993.
2. **Calculus, Early Transcendental**, H. Anton, I. Birens and Davis, John Wiley and Sons, 11^{th} Edition (2015).
3. **Differential Calculus,** Maity and Ghosh, New Central Book Agency (P) limited, Kolkata, India. 2007.
4. **Calculus: Early transcendental,** James Stewart, Brooks/ Cole Cengage Learning, 7^{th} edition (2012).

B.Sc. (Mathematics) (Part I) (Semester – II)
Choice Based Credit System with Multiple Entry and Multiple Exit Option (NEP-2020)
Syllabus to be implemented from Academic Year 2022-23

Course code: **DSC – B6**
Title of course: **Basic Algebra**
Theory: **32 Hrs. (40 lecturers)**
Marks: **50 (Credit: 02)**

Course Learning Outcomes: Upon successful completion of the course students will able to:

1. Use fundamental concepts in Mathematics like sets, relations and functions.
2. Use fundamental concepts in Number theory.
3. Solve examples on congruence.
4. Determine n^{th} roots of unity.
5. Understand various properties of hyperbolic functions.

Unit – 1: Functions, divisibility and congruence **(20 lect.)**

1.1 Set, Relations on sets, type of relations, equivalence relations, Equivalence classes and partitions of a set.

1.2 Functions: One-one, onto functions and bijections, composition of functions (Definitions and examples).

1.3 The induction principle and strong induction principle.

1.4 Divisibility and congruence:

- 1.4.1 The division algorithm: Theorem and its applications.
- 1.4.2 Definitions of Greatest common divisor least common multiple.
- 1.4.3 Euclidean Algorithm.
- 1.4.4 Fundamental Theorem of Arithmetic.
- 1.4.5 The theory of Congruence: Basic Properties of congruence.

Unit – 2: Complex numbers **(20 lect.)**

2.1 Complex numbers (Revision): Sums and Products, Basic Algebraic Properties, Moduli, complex conjugates and polar representation of complex numbers.

2.2 Theorem: De Moivre's theorem.

- 2.2.1 n^{th} roots of unity.
- 2.2.2 Examples.

2.3 Complex logarithm and complex power.

2.4 Hyperbolic functions and identities.

2.5 Relation between hyperbolic and trigonometric functions.

2.6 Identities of hyperbolic functions.

2.7 Hyperbolic equations.

2.8 Inverses of hyperbolic functions.

2.9 Derivative of hyperbolic and inverse hyperbolic functions

Recommended books:

1. **A Foundation Course in Mathematics**, Ajit Kumar, S. Kumeresan and Bhaba Kumar Sarma, Narosa Publication House.
   Unit 1 (1.1): Chapter 4: 4.1 to 4.4, (1.2): Chapter 3: 3.1 to 3.3, (1.3): Chapter 5: 5.1 to 5.2.
2. **Elementary Number Theory**, Seventh edition: David M. Burton, McGraw-Hill.
   Unit 1 (1.4): Chapter 2: 2.2 to 2.4, Chapter 3: 3.1, Chapter 4: 4.2.
3. **Foundation Mathematics for the Physical Sciences**, Riley and Hobson, Cambridge University press, 2011.
   Unit 2 (2.1 to 2.9): Chapter 5: 5.1 to 5.7.

Reference Books:

1. **Foundations of Complex Analysis**, S. Ponnusamy, Narosa Publishing House, India, Second Edition Reprint 2019.
2. **Introduction to Real Analysis**, R.G. Bartle and D.R. Sherbert, John Wiley and Sons Inc, Fourth Edition.