SHIVAJI UNIVERSITY,

KOLHAPUR.

Accredited By NAAC with 'A++' Grade

Structure and Syllabus in Accordance with

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

Bachelor of Science – Part III
(Mathematics)

Semester V and VI

under the

Faculty of Science and Technology

(To Be Implemented from Academic Year 2024-25)

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

1. Title : Mathematics
2. Year of implementation : Academic Year 2024–25
3. Duration : The duration of the course shall be one year and two semesters
4. Pattern : Semester
5. Structure of Course :

Paper-No.	Course Code	Title of the Paper	Total Marks	Theory/ Practical perweek
Semester-V				
IX	DSC-E9	Real Analysis	50	03
X	DSC-E10	Modern Algebra	50	03
XI	DSC-E11	Partial Differential Equations	50	03
XII	DSC-E12	Integral Transform	50	03
Semester-VI				
XIII	DSC-F9	Metric Spaces	50	03
XIV	DSC-F10	Linear Algebra	50	03
XV	DSC-F11	Complex Analysis	50	03
XVI	DSC-F12	Operations Research	50	03
(Semester III & IV)				
CCPM-IV		Problems on Operations Research	50	05
CCPM-V		Problems on Laplace and Fourier Transform	50	05
CCPM-VI		Mathematical Computation Using Python	50	05
CCPM-VII		Project and Study Tour	50	05

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.

B.Sc. (Mathematics) (Part III) (Semester – V and 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 : Core Course Practical in Mathematics (CCPM – IV)
Title of course : **Problems on Operations Research**
Practical : 64 Hrs. (80 lecturers of 48 min.)
Marks : 50 (Credit: 04)

Sr. No	Title of Experiment	No. of Practicals
1	Formulation of linear programming problems	1
2	Graphical method for linear programming problems	1
3	Simplex method for linear programming problems	2
4	Two Phase Method for linear programming problems	1
5	Big M Method for linear programming problems	1
6	Transportation Problems[North west corner rule]	1
7	Transportation Problems[Lowest Cost Entry Method]	1
8	Transportation Problems[Vogel Approximation Method]	1
9	Transportation Problems[Test for Optimality MODI method]	2
10	Transportation Problems [Unbalanced Problem]	1
11	Assignment Problems [Hungarian Method]	1
12	Assignment Problems [Maximization Case]	1
13	Assignment Problems[Travelling Salesman Problem]	1
14	Assignment Problems[Unbalanced Problem]	1
	Total	16

Reference Books: S. D. Sharma, Operation Research, Kedar Nath Ram Nath Publications.

B.Sc. (Mathematics) (Part III) (Semester – V and 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 : Core Course Practical in Mathematics (CCPM – V)
Title of course : **Problems on Laplace and Fourier Transform**
Practical : 64 Hrs. (80 lecturers of 48 min.)
Marks : 50 (Credit: 04)

Sr. No	Title of Experiment	No. of Practicals
1	Laplace transform of elementary functions	1
2	Evaluation of integrals using properties of Laplace transform	1
3	Effect of multiplication	1
4	Effect of division	1
5	Laplace transform of integrals	1
6	Laplace transform of periodic functions	1
7	Inverse Laplace by using standard results	1
8	Inverse Laplace by Convolution theorem	1
9	Inverse Laplace by partial fractions I	1
10	Inverse Laplace by partial fractions II	1
11	Infinite Fourier sine transform and inverse	1
12	Infinite Fourier cosine transform and inverse	1
13	Change of scale property of Fourier transform	1
14	Convolution theorem of Fourier transform	1
15	Finite Fourier sine transform and inverse	1
16	Finite Fourier cosine transform and inverse	1

Reference Books:

1. J.K.Goyal, K.P.Gupta, Integral Transforms, A Pragati Prakashan, Meerut, 21th edition, 2021.
2 Dr.S.Sreenadh, Fourier series and Integral Transform, S.Chand, New Delhi, 2021.
3. B.Davies, Integral Transforms and Their Applications, Springer Science, 2017.
4. Murray R. Spiegel, Laplace Transforms, Schaum's outlines , 2018.

B.Sc. (Mathematics) (Part III) (Semester – V and 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 : Core Course Practical in Mathematics (CCPM – VI)
Title of course : **Mathematical Computation Using Python**
Practical : 64 Hrs. (80 lecturers of 48 min.)
Marks : 50 (Credit: 04)

Sr. No	Title of Experiment	No. of Practicals
1	**Introduction to Python:** Python, IDE Spyder(Anaconda), Python Identifiers and Keywords , data types, simple mathematical operation, Indentation and Comments., Input and Output, First Python Program.	1
2	**Expression and operators:** Expression, Boolean expression, logical operations: comparison operator, membership operator, identity operator, bitwise operator. Order of evaluation. File Handling : open, read, write, append modes of file.	1
3	**Conditional Statements:** if-else, nested if-else, if-elif-else, try-except block.	1
4	**Looping Statements, Control statements:** Looping Statements: for loop, while loop , Nested loops Control Statements: break, continue and pass.	1
5	**Functions:** Built-in functions, User-defined functions, Arguments, recursive function, Python Anonymous/Lambda Function, Global, Local and Nonlocal variables and return statement.	1
6	**Modules and packages in Python :** Modules, import, import with renaming, from-import statement, math module, Numpy and sympy module.	1
7	**Python Data structure:** Strings, list, tulpes, dictionary, set and array.	1
8	**Operations on set and array:** Set operations, Intersection, union, difference, symmetric difference, searching and sorting.	1
9	**Matrix Algebra:** Addition and Multiplication of matrices	1
10	**Systems of linear algebraic equations:** Gauss Elimination Method, Gauss-Seidel Method	1
11	**Roots of Equations:** Bisection, Newton-Raphson Method	1
12	**Initial Value Problems:** Euler's Method, Runge-Kutta Second and Fourth Order Methods.	1
13	**Numerical Integration:** Trapezoidal Rule, Simpson's 1/3-rd Rule and Simpson's 3/8-th Rule	1
14	**Interpolation:** Newton's forward difference interpolation formula, Newton's backward difference interpolation formula Lagrange's interpolation formula	1

15	Magic square of order 3 and 4.	1
16	**Data visualization in Python:** 2D and 3D plot in python : line plot, bar plot, histogram plot, scatter plot, pie plot, area plot.	1

Reference Books:

1. JaanKiusalaas, ***Numerical Methods in Engineering with Python3***, Cambridge University Press.
2. Amit Saha, ***Doing Math with Python***, No Starch Press, 2015.
3. YashwantKanetkar and Aditya Kanetkar,***Let Us Python***, BPB Publication, 2019.

Sample problems:

- **Conditional Statements (if . . . else)**
  1. Write a python program to check whether a given number is maximum / minimum.
  2. Write a python program to check whether a given number is odd or even.
  3. Write a python program to check whether a given year is leap year or not.
- **Conditional Statements (for loop)**
  4. Write a python program to find sum of n natural numbers.
  5. Write a python program to find factorial of n.
  6. Write a python program to generate STAR pattern.
  7. Write a python program to generate Pascal triangle.
  8. Write a python program to find sin(x), cos(x), exp(x) using series expansion.
- **Conditional Statements (while loop)**
  9. Write a python program to find sum of n natural numbers.
  10. Write a python program to find factorial of n.
  11. Write a python program to check whether a given number is prime or not.
  12. Write a python program to find prime GCD of the given numbers.
  13. Write a python program to find reverse the given number.
  14. Write a python program to find prime factors of the given number.
- **Function and Recursive Function**
  15. Write a python function to find factorial of number and use it to find $\binom{n}{k}$.
  16. Write a python recursive function to find factorial of number and use it to find $\binom{n}{k}$.
  17. Using python recursive function write a program that convert given decimal number to binary number.

B.Sc. (Mathematics) (Part III) (Semester – V and 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	**:**	Core Course Practical in Mathematics (CCPM – VII)
Title of course	**:**	**Project and Study Tour**
Practical	**:**	64 Hrs. (80 lecturers of 48 min.)
Marks	**:**	50 (Credit: 04)

A :PROJECT

Each student of B.Sc. III is expected to read, collect, understand the culture of Mathematics, its historic development. He is expected to get acquainted with Mathematical concepts, innovations, relevance of Mathematics. Report of the project work should be submitted through the respective Department of Mathematics. Evaluation of the project report will be done by the external examiners at the time of annual examination.

B. STUDY TOUR

It is expected that the Study Tour should contain at least renown academic institution so that the visiting students will be inspired to go for higher studies in Mathematics.

C. SEMINARS:

Students should present a seminar before the B.Sc.III class on some topic in Mathematics.

D. VIVA-VOCE (on the project report).

NATURE OF QUESTION PAPER:

A. **Continuous Assessment (CA):**

Term work shall be of 10 marks for the courses of 2 credits.

B. **End Semester Assessment:**

1. End Semester examination shall be of 40 marks for the courses of 2 credits.
2. The nature of Question Paper for Theory Examination:

Maximum Marks: 40 Duration: 2 hrs.

Q. 1) Choose the correct alternative from the following and rewrite the sentence. [8]

a) to h) MCQ one mark each with four options

i) ii) iii) iv)

Q. 2) Attempt any TWO of the following [16]

a)

b)

c)

Q. 3) Attempt any FOUR of the following [16]

a)

b)

c)

d)

e)

f)

C. Practical Examination:

1. Practical examination shall be of 50 marks for the courses of 2 credits.
2. Distribution of marks: Practical question paper – 40 marks, Certified Journals – 05 marks, Viva – voce – 05 marks.
3. The nature of Question Paper for Practical Examination**(CCPM-IV,V,VI):**

Q.1 (A) (10 Marks)
(B) (05 Marks)
OR
Q.1 (A) (10 Marks)
(B) (05 Marks)

Q.2 (A) (10 Marks)
(B) (05 Marks)
OR
Q.2 (A) (10 Marks)
(B) (05 Marks)

Q.3 Attempt any TWO of the following
(A) (05 Marks)
(B) (05 Marks)
(C) (05 Marks)
(D) (05 Marks)

4. The nature of Question Paper for Practical Examination **(CCPM – VII):**

1. Project : 30 Marks (External Examiner)
2. Study Tour : 05 Marks (External Examiner)
3. Seminar : 05 Marks (External Examiner)
4. Viva Voce : 10 Marks (External Examiner)

Note: Each student of a class will select separate topic for project work. He/She should submit the reports of his/her project work, Study tour report to the department and get the same certified.

Teaching Periods:

(i) Total teaching periods for each Theory Paper (DSE E-9. E-10, E-11,E-12, F-9,F-10, F-11,F-12) are three(03) periods per paper per week (Total Theory paper workload will be 12 period per week).
(ii) Total teaching periods for Practical Paper (CCPM-IV, V, VI, VII) are five (05) periods per week per practical (Total Practical workload will be 20 period per week).

EQIVALENCE IN ACCORDANCE WITH TITLES AND CONTENTS OF PAPERS (FOR REVISED SYLLABUS

Sem - V

New Course code	Title of the course	New Course code	Title of the course
DSE E9	Mathematical Analysis	DSC E9	Real Analysis
DSE E10	Abstract Algebra	DSC E10	Modern Algebra
DSE E11	Optimization Techniques	DSC F12	Operations Research
DSE E12	Integral Transforms	DSC E12	Integral Transforms

Sem - VI

Old Paper number	Equivalence	New Course code	Title of the course
DSE F9	Metric Spaces	DSCF9	Metric Spaces
DSE F10	Linear Algebra	DSC F10	Linear Algebra
DSE F11	Complex Analysis	DSC F11	Complex Analysis
DSE F12	Discrete Mathematics	DSC F12	Partial Differential Equations

Core Course Practical in Mathematics (CCPM)

Old course code	Equivalence	New Course code	Title of the course
CCPM IV	Operations Research	CCPM IV	Problems on Operations Research
CCPM V	Laplace and Fourier Transforms	CCPM V	Problems on Laplace and Fourier Transform
CCPM VI	Mathematical Computation Using Python	CCPM VI	Mathematical Computation Using Python
CCPM VII	Project, study tour, Seminar,viva.	CCPM VII	Project and Study Tour