Punyashlok Ahilyadevi Holkar Solapur University, Solapur

NAACAccredited-2022
'B^{++}'Grade (CGPA2.96)

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

(According to NEP 2020)

Syllabus: Mathematics
Name of the Course: B.Sc. III (Sem. V & VI)

(Syllabus to be implemented from June 2026)

Punyashlok Ahilyadevi Holkar Solapur University, Solapur
Faculty of Science & Technology
Syllabus of B.Sc. Part-III-Mathematics

Preamble:

The B.Sc. III Mathematics program is designed to provide students with a strong foundation in the fundamental concepts and principles of Mathematics. Mathematics, as the language of nature and science, plays a pivotal role in understanding complex systems, solving real-world problems, and advancing technology. In the first year of this program, students will be equipped with analytical and logical thinking skills that are essential for exploring deeper mathematical theories and for applying mathematical methods to a variety of fields. This program also encourages the development of problem-solving techniques, computational skills and the ability to think abstractly.

Aims: The aim of the course is to generate Intelligent and Skillful human beings with adequate theoretical and practical knowledge of the various mathematical systems. To include conceptual understanding in basic Phenomena, statements, theorems and development of appropriate problem solving skills suitable for applications and sufficient logical connectivity has provided.

Program Outcomes:

1. Enabling students to develop a positive attitude towards mathematics as an interesting and valuable subject of study.
2. Ability to pursue advanced studies and research in pure and applied mathematical science.
3. Ability to relate scientific knowledge to real-world phenomena and applications.

4. Equipped with the skills and knowledge to pursue careers in industries such as research, teaching, healthcare, environmental science, data science, or technology.
5. Develop critical thinking and analytical reasoning skills to identify, assess and solve complex scientific problems.

Program Specific Outcomes:

1. A student should be able to recall basic facts about Mathematics and should be able to display knowledge of conventions such as notations, terminology.
2. Enabling students to develop a positive attitude towards Mathematics as an interesting and valuable subject of study.
3. Formulate and develop mathematical arguments in a logical manner.
4. Utilize Mathematics to solve theoretical and applied problems by critical understanding, analysis.
5. Develop the ability to conduct independent research in Mathematics or related interdisciplinary fields.
6. Develop a strong foundation in core areas of Mathematics, including calculus, algebra, analysis, geometry and differential equations.
7. Understanding of ethical issues in Mathematics and its applications.

B.Sc. Part-III (Semester-V & VI) Mathematics

Semester	Course Type	Course Title	Credits		Marks			
			T	PR	T-CA	PR-CA	T-UA	PR-UA
V	DSC1-7	Abstract Algebra – II	3	2	30	20	45	30
	DSC1-8	Complex Analysis	3	2	30	20	45	30
	DSC1-9	Real Analysis	3	2	30	20	45	30
	DSE1-1	Partial Differential Equations	2	1	20	10	30	15
	DSE1-2	Operations Research	2	1	20	10	30	15
	DSE1-3	Cyber Security	2	1	20	10	30	15
	VSC3	Hands on Training Related to DSE1-1 OR DSE1-2	---	2	--	20	--	30
	IKS2	Ancient Indian Mathematics	2	---	20	---	30	---
VI	DSC1-10	Metric Spaces	3	2	30	20	45	30
	DSC1-11	Numerical Analysis	3	2	30	20	45	30
	DSC1-12	Integral Calculus	3	2	30	20	45	30
	DSE1-3	Fourier Transform	2	1	20	10	30	15
	DSE1-4	Graph Theory	2	1	20	10	30	15
	VSC4	Hands on Training Related to DSE1-3 OR DSE1-4	---	2	--	20	--	30
	FP2/CEP2/OJT1	Field Projects/Internships/ Apprenticeships/ Community Engagement Projects/On-Job Training	---	2	--	20	--	30

SEMESTER – V

(I) Theory Papers:-

Paper	Course Title	Marks
DSC1-7	Abstract Algebra – II	45 + 30 = 75
DSC1-8	Complex Analysis	45 + 30 = 75
DSC1-9	Real Analysis	45 + 30 = 75
DSE1-1	Partial Differential Equations	30 + 20 = 50
DSE1-2	Operations Research	30 + 20 = 50
VSC3	Hands on Training Related to DSE1-1 OR DSE1-2	30 + 20 = 50
IKS2	Ancient Indian Mathematics	30 + 20 = 50

SEMESTER – VI

(II) Theory Papers:-

Paper	Course Title	Marks
DSC1-10	Metric Spaces	45 + 30 = 75
DSC1-11	Numerical Analysis	45 + 30 = 75
DSC1-12	Integral Calculus	45 + 30 = 75
DSE1-3	Fourier Analysis	30 + 20 = 50
DSE1-4	Graph Theory	30 + 20 = 50
VSC4	Hands on Training Related to DSE1-3 OR DSE1-4	30 +20 = 50
FP2/CEP2/OJT1	Field Projects/Internships/ Apprenticeships/ Community Engagement Projects/On-Job Training	30 + 20 = 50

Mathematics Practical

Semester-V

Practical No.	Title	Marks
Practical-7	Practical based on DSC1-7 (Abstract Algebra – II)	30 + 20 = 50

Practical-8	Practical based on DSC1-8 (CA)	30 + 20 = 50
Practical-9	Practical based on DSC1-9(RA)	30 + 20 = 50
Practical-10	Practical based on DSE1-1 (PDE)	30 + 20 = 50
	Practical based on DSC1-2 (OR)	30 + 20 = 50
Practical-11	Practical based on VSC3-1 (PDE)	30 + 20 = 50
	Practical based on VSC3-2 (PDE)	30 + 20 = 50

Semester-VI

Practical No.	**Title**	**Marks**
Practical-12	Practical based on DSC1-10 (MS)	30 + 20 = 50
Practical-13	Practical based on DSC1-11 (NS)	30 + 20 = 50
Practical-14	Practical based on DSC1-12 (IC)	30 + 20 = 50
Practical-15	Practical based on DSE1-3 (FA)	30 + 20 = 50
	Practical based on DSC1-4 (GT)	30 + 20 = 50
Practical-16	Practical based on VSC3-3 (FA)	30 + 20 = 50
	Practical based on VSC3-4 (GT)	30 + 20 = 50

Semester-V

Paper Name: Abstract Algebra – II	**Course Code:**
Paper Number: DSC1-7	**Credits: 03**

Course Objectives: To learn about to

1 Focus the students from computational mathematics to conceptual mathematics, proof-based reasoning by exploring the fundamental structures that underlie modern science and engineering.

2. Move beyond simple 2D or 3D geometry to understand the abstract properties of vector spaces, including linear independence, spanning sets, bases, and dimensions

3. Analyze how matrices act as functions (transformations) between vector spaces, exploring concepts like the rank-nullity theorem, kernel, and image.

4. Generalize mathematical operations and to study structures like groups, rings, and fields, moving away from specific numbers to focus on universal algebraic rules.

Unit	Content	Hours
I	**Introduction to Rings:** Definitions and Examples, Integral Domains, Subrings, Fields, Isomorphism, Characteristic of rings, Homomorphism of rings, ideals, Quotient Rings.	10
II	**Vector Spaces:** Vector spaces, subspaces, Linear combinations and system of linear equations, Linear dependence and linear independence, bases and dimension.	15
III	**A. Linear transformation and matrices:** Linear transformation, null spaces and range, The matrix representation of linear transformation, composition of linear transformations and matrix multiplication, Invertibility and Isomorphisms.	15
	B. Inner product spaces: Inner products and norms, The Gram-Schmidt orthogonalization process and orthogonal complements.	05

Course Outcomes:

After Completing this course, students will be able to:

1. Describe the fundamental concepts in ring theory such as of the ideals, quotient rings, integral domains and fields.
2. Demonstrate the concepts of vector spaces, subspaces, bases, dimension and their properties with examples.
3. Identify matrices with linear transformations.
4. Apply the Gram-Schmidt orthogonalization process.
5. Use software tools (like Python or MATLAB) to perform large-scale matrix operations.
6. Apply abstract algebra principles to real-world scenarios, such as creating error-correcting codes or analyzing symmetries in physics.
7. Formulate and interpret the basic facts and constructions of algebraic theory in both speech and writing.

Recommended Book:

1. **Modern Algebra – An Introduction, by John R. Durbin,** John Wiley & Sons, Inc. Fifth Edition.

Scope of syllabus:

Unit VI:- 24, 25, 26, 27

Unit IX:- 38, 39

2. **Linear Algebra** - Fourth Edition by Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Prentice Hall of India.

Scope of syllabus:

Unit 1 :- 1.1, 1.2, 1.3, 1.4, 1.5

Unit 2 :- 2.1, 2.2, 2.3, 2.4, 2.5

Unit 6 :- 6.1, 6.2

Reference Books:

1. A First Course in Abstract Algebra J. B. Fraleigh, Pearson Education 7th edition
2. Abstract Algebra David S. Dummit & Richard M. Foote Wiley & Sons, Inc.
3. Fundamentals of Abstract Algebra D. S. Malik & N. Mordeson& M. K. Sen Mc. Graw Hill International Edition.
4. A Course in Abstract Algebra by Vijay K. Khanna and S.K. Bhambri, Vikas Publishing House Pvt. Ltd.
5. Linear Algebra by Vivek Sahai &Vikas Bist, Narosa Publishing House.
6. Linear Algebra by Serge Lang Wesley publishing company.
8. Linear Algebra by Hoffman and Kunze Prentice Hall, Inc., New Jersey.
9. Linear Algebra A Geometric Approach By Kumaresan, LIBRARIAN IECW.

Paper Name: Abstract Algebra – II	**Course Code:**
Paper Number: DSC1-7(P)	**Credits: 02**

Course Objectives: To learn about to

1. Define and analyze vector spaces, subspaces, basis, dimension, linear transformations, matrices.
2. Develop proficiency in abstract structures, including groups, rings, fields.
3. Master techniques like Gaussian elimination, matrix inversion, diagonalisation, and solving systems of linear equations.
4. Apply linear algebraic techniques to fields like cryptography, quantum mechanics, computer science, and data analysis.
5. Build skills in mathematical proofs and theoretical understanding. Understanding linear transformations, orthogonality, inner product spaces.
6. Understand algebraic structures, homomorphisms, and their applications.

Expt. No.	Title	Hours
1	Numerical problems based on definitions and examples of rings	4
2	Numerical problems based on Integral Domains, Subrings, Fields.	4
3	Numerical problems based on isomorphism, characteristic of rings, homomorphism of rings.	4
4	Numerical problems based on ideals, quotient Rings	4
5	Numerical problems based on vector spaces, subspaces	4
6	Numerical problems based on linear combinations and system of linear equations	4
7	Numerical problems based on linear dependence and linear independence, bases and dimension	4

8	Numerical problems based on linear transformation, null spaces and range.	4
9	Numerical problems based on the matrix representation of linear transformation, composition of linear transformations and matrix multiplication	4
10	Numerical problems based on invertibility and isomorphisms	4
11	Numerical problems based on inner products and norms	4
12	Numerical problems based on the Gram-Schmidt orthogonalization process and orthogonal complements	4
13	Revision on expts-1 – 3	4
14	Revision on expts-4 – 6	4
15	Revision on expts-7 – 10	4

Course Outcomes:

After Completing this course, Students will be able to:

Define and analyze vector spaces, subspaces, basis, dimension, linear transformations, and matrices.

1. Develop proficiency in abstract structures, including groups, rings, and fields.
2. Master the techniques like Gaussian elimination, matrix inversion, diagonalisation, and solving systems of linear equations.
3. Apply linear algebraic techniques to fields like cryptography, quantum mechanics, computer science, and data analysis.
4. Build skills in mathematical proofs and theoretical understanding. Understanding linear transformations, orthogonality, inner product spaces.

Paper Name: Complex Analysis	**Course Code:**
Paper Number: DSC1-8	**Credits: 03**

Course Objectives:

To learn about to:

1. Understand complex variables, functions, limits, continuity, and differentiability.
2. Analyze Cauchy-Riemann equations and harmonic functions.
3. Represent functions using Taylor and Laurent series and identify singularities.
4. Compute residues and apply the residue theorem to evaluate integrals.

Unit	Content	Hours
I	**Analytic Functions:** Complex Differentiation, Limits and Continuity, Differentiability Necessary and sufficient condition of analytic function, Method of constructing a regular function and analytic function, Simple method of constructing analytic function, Polar from of Cauchy-Riemann Equations.	10
II	**Complex Integration:** Introduction, Some basic definitions, Complex integral, Reduction of complex integrals to real integrals, Some properties of complex Integrals, An estimation of a complex integral, Line integrals as functions of arcs, Cauchy's Fundamental Theorem (Theorem-I), Cauchy Goursat Theorem [Statement Only], Cauchy's Integral formula [Statement only], its consequences and examples, Derivative and higher order derivatives of an analytic function [Statement(s) only] and examples, Expansions of Analytic functions as power series (Taylor's Maclaurin's and Laurent's Series [Statement only]) and its examples, The zeros of an analytic function, Different Types of Singularities, Some Theorems on Poles and other Singularities (Theorem-I to IV only) and its examples, The point at infinity .	20
III	**Calculus of Residues:** Residue at simple pole, Residue at a Pole of order greater than unity, Residue at infinity, Cauchy's Residue Theorem. Evaluation of Definite integrals, Integration round the unit Circle. Evaluation of $\int_0^{2\pi} f(\cos\theta, \sin\theta)\mathrm{d}\theta$.	15

Course Outcomes:

After Successful completion of the course, students will be able to:

1. Define, analyze, and apply concepts of complex numbers, limits, continuity, differentiability, and Cauchy-Riemann equations.
2. Determine if a function is analytic, identify harmonic functions, and construct harmonic conjugates.
3. Compute line integrals using Cauchy's theorem, Cauchy-Goursat theorem, and Cauchy's integral formulas.
4. Represent functions using Taylor and Laurent series, and classify singularities and poles.

Recommended Book:

Functions of Complex Variable by J.N. Sharma Revised by Dr. Shanti Swarup, (38 Edition) Krishna Prakasha Media Ltd., Meerut.

Scope of syllabus:

Chapter - 2 (Analytic Functions): 1 to 7

Chapter - 6 (Complex Integration): 1 to 8, 9 (Statement only), 19 (Theorem-1, Theorem- II (Statements only), 20, 21, 22 [Theorems I to IV only], 23, 24.
Chapter- 7 (Calculus of Residues): 1 to 6

Reference Books:

1. Graduate texts in mathematics functions of one complex variable – J.B.Conway.
2. Theory of functions of a complex variables- Shanti Narayan ,P.K.Mittal, Chand Publication.
3. A function of complex variable by A.R.Vashishtha.
4. Complex variables and applications by J.W.Brown ,J.R.Churchill.
5. Complex Variables and Applications – James Ward Brown &Ruel V. Churchill.
6. Fundamentals of Complex Analysis with Applications to Engineering and Science – Edward B. Saff& Arthur David Snider.
7. Basic Complex Analysis – Jerrold E. Marsden & Michael J. Hoffman.
8. Complex Analysis – Elias M. Stein & Rami Shakarchi (Part of a reputable Princeton lecture series)
9. Complex Variables – Stephen D. Fisher.
10. Basic Complex Analysis **by** Jerrold E. Marsden & Michael J. Hoffman**:** A well-structured, classic undergraduate text that combines theory with applications

Paper Name: Complex Analysis	**Course Code:**
Paper Number: DSC1-8(P)	**Credits: 02**

Course Objectives:

To learn about to:

1. Develop skills in performing arithmetic operations on complex numbers, including finding the modulus, conjugate, and phase angle.
2. Compute integrals over paths, evaluate contour integrals, and determine poles and residues for complex functions.
3. Perform Taylor and Laurent series expansions for given functions at specific points.
4. Analyze power series and their radius of convergence.

Expt. No.	**Title**	**Hours**
1	Numerical Problem based on Finding the regular (analytic) function of which function (real, Imaginary,$u+v$,$u-v$ type.)	4
2	Numerical Problem based on Necessary and Sufficient Condition for Differentiability	4
3	Numerical Problem based on Cauchy-Rieman equation	4
4	Numerical Problem based on complex integration	4

	Circle, Line and Parabola.	
5	Numerical Problem based on Calculus of residue.	4
6	Numerical Problem based on Integration round the unit circle.	4
7	Numerical Problem based on Evaluation of integral $\int_0^{2\pi} f(\cos\theta, \sin\theta)\,d\theta$.	4
8	Numerical Problem based on Obtain the Taylor's and Laurent's series.	4
9	Numerical Problem based on Cauchy integral formula	4
10	Numerical Problem based on Singularity	4
11	Numerical Problem based on Residues Zeros of analytic unction	4
12	Numerical problems based Evaluation of Definite integrals.	4
13	Revision on expts-1 – 3	4
14	Revision on expts-4 – 6	4
15	Revision on expts-7 – 10	4

Course Outcomes:

After Successful completion of the course, Students will be able to:

1. Verify the analyticity of complex functions by computing partial derivatives and applying Cauchy-Riemann equations.
2. Identify and classify singularities (poles, removable, essential) and determine the behavior of functions near these points.
3. Verify the analyticity of complex functions by computing partial derivatives and applying Cauchy-Riemann equations.
4. Calculating complex integrals along paths in the complex plane.

Paper Name: Real Analysis	**Course Code:**
Paper Number: DSC1-9	**Credits: 03**

Course Objectives:

To learn about to:

1. Develop a rigorous understanding of the real number system, including supremum and infimum.
2. Understand sequences and series of real numbers, including convergence tests and Cauchy criteria.
3. Study concept and elementary results of real-valued functions.
4. Study sequences and series of functions, including:
    - Convergence and divergence
    - Bounded Sequences

- Monotonic sequences etc.

Unit	Content	Hours
I	**Sets and Function** 1.1 Sets and elements 1.2 Operations on sets 1.3 Functions 1.4 Real Valued functions 1.5 Equivalence, countability	15
II	**Sequences of real numbers** 2.1 Definition of sequence and subsequence 2.2 Limits of sequence 2.3 Convergent sequences 2.4 Divergent sequences 2.5 Bounded sequences 2.6 Monotonic sequences 2.7 Operations on convergent sequences 2.8 Operations on divergent sequences 2.9 Limit superior and limit inferior 2.10 Cauchy sequences	15
III	**Series of real numbers** 3.1 Convergence and divergence 3.2 Series with non negative terms 3.3 Alternating Series 3.4 Conditional convergence and absolute convergence 3.5 Test for absolute convergence (Comparison test, Ratio test, Root test) 3.6 Series whose terms form non increasing sequences	15

Course Outcomes:

After successful completion of the course, students will be able to:

1. Demonstrate a rigorous understanding of the real number system, including completeness property, supremum, and infimum.
2. Analyze and determine convergence of sequences and series of real numbers using standard tests and Cauchy criteria.
3. Construct clear and rigorous mathematical proofs using logical reasoning and standard analytical techniques.
4. Apply analytical concepts to solve theoretical and applied problems and prepare for higher studies in pure and applied mathematics.

Recommended Book:

Methods of Real Analysis by R. R. Goldberg John Wiley & sons 1976

Scope of syllabus:

Unit – 1: Art: 1.1 to 1.5
Unit – 2: Art: 2.1 to 2.10
Unit – 3: Art: 3.1 to 3.4 and 3.6 and 3.7

Reference Books:

1. A First course in Mathematical Analysis by D. Somasundaram & B. Choudhary Narosa Publishing House.
2. Mathematical Analysis second edition by S. C. Malik and Savita Arora.
3. Principles of Mathematical Analysis by Rudin W. McGraw – Hill, New York.
4. A Course of Mathematical Analysis by Shanti Narayan, S. Chand and company New Delhi
5. Real Analysis – R. R. Goldberg
6. Principles of Mathematical Analysis – Walter Rudin
7. A Course of Mathematical Analysis – Shanti Narayan
8. Introduction to Real Analysis – Robert G. Bartle & Donald R. Sherbert
9. B.Sc.. Mathematics Real Analysis (Semester III) – S. J. Alandkar, N. I. Dhanshetti, A. S. Dhone, R. D. Mahimkar
10. Higher Engineering Mathematics , B.S. Garewal , Khanna Publication

Paper Name: Real Analysis	**Course Code:**
Paper Number: DSC1-9(P)	**Credits: 02**

Course Objectives:

To learn about to:

1. To understand fundamental concepts of sequences, series through practical experiments and computational methods.
2. To verify and visualize important theorems of real analysis using numerical techniques.
3. To develop the ability to analyze convergence and divergence of sequences and series practically.
4. To enhance logical reasoning and analytical thinking through experimental verification of mathematical results.

Expt. No.	Title	Hours
1	Numerical problems based on sets and operations on sets.	4
2	Numerical problems based on real valued functions.	4
3	Numerical problems based on countability of sets and functions.	4
4	Numerical problems based on limits of sequences	4
5	Numerical problems based on convergent and divergent sequences.	4
6	Numerical problems based on bounded and monotonic sequences.	4
7	Numerical problems based on operations on convergent and divergent sequences.	4
8	Numerical problems based on limit superior and limit inferior.	4
9	Numerical problems based on convergence and divergence series.	4
10	Numerical problems based on series with non negative	4

	terms and alternating series.	
11	Numerical problems based on conditional convergence and absolute convergence.	4
12	Numerical problems based on test for absolute convergence by comparison test, ratio teat and root test.	4
13	Revision on expts-1 – 3	4
14	Revision on expts-4 – 6	4
15	Revision on expts-7 – 10	4

Course Outcomes:

After successful completion of this course, students will be able to:

1. Understand and analyze sequences and series and determine their convergence or divergence through numerical methods.
2. Compute limits and verify continuity of real-valued functions using computational approaches.
3. Apply theorems of real analysis to practical problems and verify them experimentally.
4. Interpret mathematical results obtained from practical experiments and relate them to theoretical concepts of real analysis and develop analytical and problem-solving skills useful for higher studies in mathematics

Paper Name: Partial Differential Equations	**Course Code:**
Paper Number: DSE1-1	**Credits: 02**

Course Objectives:

To learn about to:

1. Understand the basic concepts of Partial Differential Equations, including formation, and identifying order/degree of PDEs.
2. Develop skills to solve first-order PDEs using various standard methods such as: Lagrange's linear equation
3. Develop skills to solve first-order PDEs using various standard methods such as: Charpit's method
4. Solve first-order linear and non - linear PDEs with constant coefficients, including:
    - Complementary function and particular integral
    - Homogeneous equations
    - Introduction to non - homogeneous equations.

Unit	Content	Hours
I	**Linear Partial differential equation of order one** 1.1 Partial Differential Equation 1.2 Order of a partial differential equation 1.3 Degree of a partial differential equation	10

	1.4 Linear and non-linear partial differential equations 1.5 Classification of first order partial differential equation 1.6 Derivation of partial differential equation by eliminating arbitrary constants 1.7 Derivation of partial differential equation by eliminating arbitrary functions 1.8 Lagrange's Method of solving Pp + Qq = R when P, Q and R are functions of x, y, z. 1.9 Integral surface passing through a given curve	
II	**Non Linear partial differential equation of order one** 2.1 Explanation of terms and problems on complete integral, particular integral, singular integral and general Integral as applied to solutions of first order partial differential equations 2.2 Geometrical interpretation of three types if integrals of $f(x, y, z, p, q) = 0$ 2.3 Method of getting singular integral directly from the partial differential equation of first order 2.4 Compatible system of first order equations 2.5 Charpit's Method 2.6 Special methods of solution applicable to certain standard form I, II, III, IV.	10
III	**Homogeneous Linear partial differential equation with constant Coefficients** 3.1 Homogeneous and Non – Homogeneous linear equation with constant coefficients 3.2 Solution of a homogeneous linear partial differential equation with constant coefficients 3.3 Method of finding the complementary function (C.F.) of the linear homogeneous partial differential equation with constant coefficients (without proofs) 3.4 Working rule for finding complementary function (C.F.) of linear homogeneous partial differential equation with constant coefficients 3.5 Particular integral (P.I.) of the linear homogeneous partial differential equation with constant coefficients 3.6 Short method I when f (x, y) is of the form f (ax + by) (without proof) 3.7 Short method II when f (x, y) is of the form $x^m y^n$ (without proof) 3.8 A general method of finding the particular integral of linear homogeneous equation with constant coefficients	10

Course Outcomes: After successful completion of the course, students will be able to:

1. Classify partial differential equations according to order, degree, and form PDEs by eliminating arbitrary constants and functions.
2. Solve first-order partial differential equations using standard methods such as Lagrange's method, Charpit's method, and compatible systems.
3. Solve first-order homogeneous equations using standard methods of finding Complementary function and particular integral.
4. Identify the difference between homogeneous and non-homogeneous partial differential equations.

Recommended Book: Ordinary and partial differential equation by M. D. Raisinghania, S. Chand Co. [PART - III] 16 th edition.

Scope of syllabus:

Unit - 1: Chapter -1: 1.2 to 1.12 and Chapter -2: 2.1 to 2.15
Unit - 2: Chapter -3: 3.1 to 3.18
Unit - 3: Chapter - 4: 4.1 to 4.13

Reference Books:

1. Elements of partial differential equations by IAN Sneddon International students edition by McGraw Hill Book
2. Differential equations Sharma & Gupta (Krishna Prakashan Media (P) Ltd. Meerut
3. Partial Differential Equations , Purna Chandra Biswal , PHI Learning Pvt. Ltd.
4. Partial Differential Equations by J. M. Kar.
5. Partial Differential Equations I: Basic TheoryMichael E. TaylorSpringer Nature
6. Partial Differential Equations – R.D. Mahimkar ,Nirali Publication Pune.
7. Introduction to Partial Differential Equations, K. Sankara Rao ,PHI Learning / Prentice Hall of India
8. Partial Differential Equations: An Introduction ,Walter A. Strauss, Wiley Publication
9. Advance Partial Differential Equations, Sudhir K. Pundir ,PragatiPrakashan, Meerut
10. Ordinary and Partial Differential Equation , Ravendra Kumar , Mahaveer Publications

Paper Name: Partial Differential Equations	**Course Code:**
Paper Number: DSE1-1(P)	**Credits: 01**

Course Objectives: To learn about to:

1. Apply theoretical concepts of Partial Differential Equations to solve practical and computational problems.
2. Solve first-order PDEs using analytical techniques and verify results through structured problem-solving approaches.
3. Enhance analytical thinking, numerical skills, and problem-solving ability required for advanced studies and applied fields.
4. Construct clear and rigorous mathematical proofs using logical reasoning and standard analytical techniques and Apply analytical concepts to solve theoretical and applied problems and prepare for higher studies in pure and applied mathematics.

Expt.	**Title**	**Hours**

No.		
1	Numerical problems based on solution of Linear Differential Equation of first order by eliminating arbitrary constants	4
2	Numerical problems based on solution of Linear Differential Equation of first order by eliminating arbitrary functions.	4
3	Numerical problems based on solution of Linear Differential Equation of first order by Lagrange's Method.	4
4	Numerical problems based on complete integral, particular integral, singular integral and general Integral as applied to solutions of first order partial differential equations.	4
5	Numerical problems based on solution of Non-linear Partial Differential Equation of first order by Charpit's Method.	4
6	Numerical problems based on finding C.F. and P.I. of Homogeneous Linear Partial Differential Equation with constant coefficients.	4
7	Revision on above experiments	4

Course Outcomes:

After successful completion of the course, students will be able to:

1. Classify partial differential equations according to order, degree, and form PDEs by eliminating arbitrary constants and functions.
2. Solve first-order partial differential equations using standard methods such as Lagrange's method, Charpit's method, and compatible systems.
3. Solve first-order homogeneous equations using standard methods of finding Complementary function and particular integral.
4. Identify the difference between homogeneous and non-homogeneous partial differential equations.

Paper Name: Hands on Training based on DSE1-1 (PDE)	**Course Code:**
Paper Number: VSC3	**Credits: 02**

Course Objectives:

To learn about to:

1. Understand the basic concepts of Partial Differential Equations, including formation, and identifying order/degree of PDEs.
2. Develop skills to solve first-order PDEs using various standard methods such as: Lagrange's linear equation

3. Solve first-order linear and non - linear PDEs with constant coefficients, including: Complementary function and particular integral
4. Solve Homogeneous equations and non - homogeneous equations.

Expt. No.	Title	Hours
1	Numerical problems based on solution of Linear Differential Equation of first order by Lagrange's Method.	4
2	Numerical problems based on Integral surface passing through a given curve.	4
3	Numerical problems based on Compatible system of first order equations.	4
4	Numerical problems based on Special methods of solution applicable to certain standard form I and II.	4
5	Numerical problems based on Special methods of solution applicable to certain standard form III and IV.	4
6	Numerical problems based on finding C.F. of the problems having distinct roots.	4
7	Numerical problems based on finding C.F. of the problems having repeated roots.	4
8	Numerical problems based on finding P.I. when f (x, y) is of the form f (ax + by)	4
9	Numerical problems based on finding P.I. when f (x, y) is of the form $x^m y^n$	4
10	Numerical problems based on finding P.I. of linear homogeneous equation with constant coefficients by using general method.	4

Course Outcomes: After successful completion of the course, students will be able to:

1. Classify partial differential equations according to order, degree, and form PDEs by eliminating arbitrary constants and functions.
2. Solve first-order partial differential equations using standard methods such as Lagrange's method, Charpit's method, and compatible systems.
3. Solve first-order homogeneous equations using standard methods of finding Complementary function and particular integral.
4. Identify the difference between homogeneous and non-homogeneous p.d.e

Paper Name: Operations Research	Course Code:
Paper Number: DSE1-2	Credits: 02

Course Objectives: To learn about to

1. Determining the best way to allocate limited, scarce resources among competing activities.
2. Assisting managers in making better, faster, and more confident decisions through quantitative, scientific analysis.
3. Identifying the best (optimum) solution to complex problems by analyzing alternative courses of action.

4. Developing models to represent real-world problems and simulate, analyze, and predict outcomes.

Unit	Content	Hours
I	**Modelling with Linear Programming:** Two variable Linear Programming Model, Solution of Linear Programming Model by Graphical Method, Applications of Linear Programming in Production Planning and Inventory Control (Single Period Production Model, Multiple Period Production Inventory Model, Multiple period Production Smoothing Model), Manpower Planning .	10
II	**Transportation and Assignment Model:** Definition of the Transportation model, The Transportation Algorithm, Determination of starting solution (Northwest-corner method, least cost method, Vogel Approximation Method(VAM)), Iterative Computations of the Transportation Algorithm, The Assignment Model, The Hungarian method, Simplex explanation of the Hungarian method).	10
III	**Games Theory:** Introduction, Some basic definitions as Saddle point, Payoff matrix, strategy, Optimal Solution of Two- person Zero Sum Game, Solution of Mixed strategy Games (Graphical Solution of games, Linear programming solution of games)	10

Course Outcomes: After successful completion of the course, students will be able to:

1. Ability to formulate mathematical models (linear programming) for quantitative analysis of industrial problems.
2. Proficiency in solving transportation, assignment, and resource allocation problems to achieve optimal results.
3. Skill in applying network models (CPM and PERT) for project management and scheduling.
4. Understanding game theory and decision analysis to guide management choices.

Recommended Book:

Hamdy A. Taha, Operation Research (9thEdition), Pearson Education Inc.

Scope of syllabus:

Unit I: Chapter-2: Art. 1, 2, 4.2, 4.3.

Unit II:Chapter-5:Art.1, 3(3.1, 3.2), 4(4.1, 4.2)
Unit III:Chapter-13:Art.4(4.1, 4.2)

Reference Books:

1. S.D. Sharma: Operation Research, kedarNath Ram Nath& Company

2. Introduction to Operations Research by F.S. Hillier & G.J. Lieberman (Best for conceptual, mathematical rigor).
3. Operations Research: Applications and Algorithms by Wayne L. Winston (Excellent for modeling and practical applications)
4. Schaum's Outline of Operations Research by Richard Bronson (Excellent for solved problems)
5. Linear Programming by V. Chvátal (Classical text on LP)
6. Network Flows: Theory, Algorithms, and Applications by R.K. Ahuja, T.L. Magnanti, & J.B. Orlin.
7. Applied Integer Programming: Modeling and Solution by D. Chen, R.G. Batson, & Y. Dang.
8. Operations Research: A Practical Introduction by Michael W. Carter & Camille C. Price
9. Operations Research by KantiSwarup, P.K. Gupta, and Man Mohan
10. Operations Research: Principles and Practice by Ravindran, Phillips, and Solberg

Paper Name: Practical based on DSE1-2 (Operations Research)	**Course Code:**
Paper Number: DSE1-2(P)	**Credits: 01**

Course Objectives: To learn about to

1. Provide hands-on experience in solving complex optimization problems using software tools and manual algorithms.
2. Enable interpretation of optimal solutions and conduct sensitivity analysis to understand the impact of changes in constraints or costs.
3. Apply OR techniques to practical scenarios, including production planning, inventory management, and network analysis.
4. Develop skills for optimizing resource usage, such as maximizing profit or minimizing costs/time.

Expt. No.	Title	Hours
1	Numerical problems based on LLPs by graphical Method	4
2	Numerical problems based on LLPs by Production Planning	4
3	Numerical problems based on Inventory control	4
4	Numerical problems based on man power planning	4
5	Numerical problems based on Northwest-Corner Method	4
6	Numerical problems based on Least cost Method	4
7	Revision on above experiments Graphical Solution of Games	4

Course Outcomes: After successful completion of the course, students will be able to:

1. Ability to define, structure, and model real-world business problems into linear programming models (LPP), including identifying objective functions and constraints.

2. Proficiency in applying algorithms to solve transportation, assignment, and sequencing problems using methods like Hungarian.
3. Hands-on experience using optimization software to solve complex operational, inventory, and network problems.
4. Capability to analyze sensitivity, interpret, and report on the consequences of different scenarios for enhanced managerial decision-making.

Paper Name: Hands on Training based on DSE1-2(OR)	**Course Code:**
Paper Number: VSC3	**Credits: 02**

Course Objectives:

To learn about to:

1. Develop the ability to translate verbal, real-world industrial or business problems into mathematical models.
2. Enable the use of quantitative techniques (linear programming, transportation, assignment models) to maximize profit or minimize costs (e.g., in logistics, production, scheduling).
3. Train students to solve complex OR problems using software tools such as Excel Solver, MATLAB, Python libraries, or specialized simulation software.
4. Teach techniques to build simulations (e.g., Monte-Carlo) to analyze and optimize system performance before actual implementation.

Expt. No.	**Title**	**Hours**
1	Numerical problems based on two variable linear Programming Model	4
2	Numerical problems based on solution of Linear Programming Model by Graphical method	4
3	Numerical problems based on Payoff Matrix	4
4	Numerical problems based on Transportation Algorithm	4
5	Numerical problems based on Hungarian Method	4
6	Numerical problems based on Simplex explanation of the Hungarian method	4
7	Numerical problems based on Vogel Approximation	4
8	Numerical problems based on solution of Mixed strategy games	4
9	Numerical problems based on linear programming solution of games	4
10	Numerical problems based on optimal solution o	4

	two person zero sum game	

Course Outcomes: After successful completion of the course, students will be able to:

1. Ability to translate verbal descriptions of real-world systems into logical, quantitative, or simulation models
2. Develop linear programming (LP), integer programming, and network models to optimize resource allocation.
3. Construct simulation models to imitate real-world processes, such as queuing systems, to evaluate performance without disrupting actual operations.
4. Apply specific algorithms (e.g., Simplex, Hungarian method) to solve transportation, assignment, and scheduling problems.
5. Interpret raw data to identify trends, bottlenecks, and optimal solutions within operational constraints.

Paper Name: Ancient Indian Mathematics	**Course Code:**
Paper Number: IKS2	**Credits: 02**

Course Objectives: To learn about to

1. To know the contribution of Indian Mathematicians in the development of Mathematics.
2. To understand various methods and concepts in Mathematics in ancient India.
3. To find interlink between methods in ancient Indian Mathematics to Modern Mathematics.

Unit	Content	Hours
I	**A. Great Mathematicians and Their Contribution Arithmetic** 1.1 Square of a number 1.2 Series and progressions 1.3 Square root of Imperfect Squares 1.4 Fun and Practicality in Indian Mathematics	07
	B. Geometry 2.1 Property of Right-angled Triangle in Sulba-Sutras 2.2 The Value of pi	08
II	**A. Trigonometry** 3.1 Computation of the 'R sines' 3.2 Aryabhata's Formula for R sine Differences 3.3 Nilakantha's Formula for R sine Differences	08
	B. Algebra	07

	4.1 Binary Mathematics and Combinatorial Problems In Chanrdah-Sastra of Pingala (300 BCE) 4.2 Magic Squares in India Construction of a 4 x 4 Pan-diagonal Magic Square	

Course Outcomes: After successful completion of the course, students will be able to:

1. Know methods and concepts in Mathematics in ancient India.
2. Find connections between methods in ancient Indian Mathematics to Modern Mathematics
3. Find solutions to different kind problems will be developed among students.

Recommended Book:

Introduction to Indian Knowledge System: Concepts and Applications by B. Mahadevan, V. R. Bhat and Nagendra Pavan R. N. PHI Learning Pvt. Ltd., Delhi 2022.

Scope of syllabus:
Chapter 8:

Unit 1 A) 8.2, 8.3, 8.3.1, 8.3.2, 8.3.3.

Unit 1 B) 8.4, 8.4.2

Unit 2 A) 8.5

Unit 2 B) 8.6, 8.7, 8.8

Reference Books:

1. Datta, B. and Singh, A.N. (1962). History of Hindu Mathematics: Parts I and II, Asia Publishing House, Mumbai
2. Datta,B. (1932). Ancient Hindu Geometry: The Science of Sulbas, Calcutta University Press, Reprinted Cosmos Pug., New Delhi, 1993.
3. Joseph.GG. (1990). The Crest of the nPeacock: Non-European Roots of Mathematics, Penguin, London.
4. Joseph G.G. (2009). A Passage to Infinity: Medieval Indian Mathematics fromKerala and Its impact. Sage, New Delhi.
5. Kedarnath (1938). Chandah Sâstra of Pigala with Commentary Mrtasañjivani of Halayudha Bhata, 3rd ed, Mumbayyn: Nirrnayasgarakhyamudranye, Mumbai.
6. Kolachana, A., Mahesh K. and Ramasubramanian, K. (2019). "Hindu mathematics in the seventhcentury as found in Bhskara I's commentary on the Aryabhaiya (IV", In: Kolachana A., Mahesh K., Ramasubramanian K. (Eds), Studies in Indian Mathematics

and Astronomy, Sources and Studies in the History of Mathematics and Physical Sciences, Springer, Singapore.

7. Madhusudana Sastri (1994). Vrttaratnkara of Kedâra with Commentaries Nrâyai and Setu'". Chaukhamba, Varanasi.
8. Parameswaran, S. (1998). The Golden age of Indian Mathematics, Swadeshi Science Movement, Kerala.
9. Vedic Geometry (Baudhayan Triples) by S.L. Maurya
10. Mathematics in Ancient India by Amartya Kumar Dutta.

SEMESTER – VI

Paper Name: Metric Spaces	**Course Code:**
Paper Number: DSC1-10	**Credits: 03**

Course Objectives:

To learn about to:

1. Develop a clear understanding of the concept of limits of functions on the real line and in metric spaces, including one-sided limits and operations on limits.
2. Understand the structure of metric spaces, including examples, open balls, Cauchy sequences, and inequalities such as Schwarz and Minkowski inequalities.
3. Explain and analyze continuity in metric spaces, including algebra of continuous functions, open and closed sets, dense sets, and homeomorphisms.
4. Understand important topological properties such as completeness, compactness, boundedness, totally bounded sets, and apply major theorems like Heine–Borel theorem and Picard fixed point theorem.

Unit	Content	Hours
I	**Limits and Metric Spaces:** The Class l^2 (Schwartz, Minkowski inequality). Limit of a function on the real line. Examples on limits, one sided limit, Metric Spaces, examples on metric spaces and Limits in metric spaces. Operations on limits, Cauchy Sequences.	14
II	**Continuous Functions on Metric Spaces:** Functions continuous at a point on the real line. Algebra of continuous functions, Reformulation, Open ball/sphere, Examples, Function continuous on a metric space, Proofs of the various theorems using open ball definition. Open Sets and Closed Sets. Homeomorphism and dense in M.	15
III	**A. Completeness:**	8

	Bounded sets and totally bounded sets, definition, examples theorems and proofs. Epsilon dense with theorems. Complete metric spaces, examples, theorems with proofs. Contraction mapping, examples and Picard fixed point theorem.	
	B. Compactness: Definition, Theorems and their consequences. Open covering, Heine-Borel property. Heine-Borel theorems. Finite intersection property and FIP theorem. Continuous functions on compact metric spaces. Continuity of the inverse function.	8

Course Outcomes:

After successful completion of this course, students will be able to:

1. Define and compute limits of functions on the real line and metric spaces, and verify properties of limits and Cauchy sequences.
2. Analyze and construct examples of metric spaces, and apply inequalities such as Schwarz and Minkowski inequalities in problem solving.
3. Demonstrate the concept of continuity in metric spaces using open ball definitions and determine open sets, closed sets, dense sets, and homeomorphisms.
4. Apply the concepts of completeness and compactness, including Heine–Borel theorem, finite intersection property, and contraction mapping theorem, to prove theoretical results and solve problems.

Recommended Book: Methods of real analysis by R. R. Goldberg, John Wiley & Sons 1976.

Scope of syllabus:

Unit - I: Limits and metric spaces Art: 3.10, 4.1 to 4.3

Unit - II: Continuous functions on metric spaces Art: 5.1 to 5.5

Unit - III: A. Completeness Art: 6.1, 6.4

B. Compactness Art: 6.5, 6.6 and 6.7

Reference Books:

1. Walter Rudin – *Principles of Mathematical Analysis*, McGraw-Hill.
   (A classic reference for real analysis including metric space concepts.)
2. S. Shirali and H. L. Vasudeva – *Metric Spaces*, Springer / Universities Press.
   (A widely used textbook focusing entirely on metric spaces.)
3. Mícheál O'Searcoid – *Metric Spaces*, Springer Undergraduate Mathematics Series.
   (Contains detailed theory with examples and exercises.)
4. E. T. Copson – *Metric Spaces*, Cambridge University Press.
   (An introductory text explaining metric space theory clearly.)
5. Stephen Abbott – *Understanding Analysis*, Springer.
   (An accessible book covering limits, continuity, and compactness.)
6. R. G. Bartle and D. R. Sherbert – *Introduction to Real Analysis*, Wiley.
   (Covers limits, metric spaces, continuity, and compactness.)
7. Dhananjay Gopal, Aniruddha Deshmukh, Abhay Ranadive, Shubham Yadav – *An Introduction to Metric Spaces*, Routledge. (Includes completeness, compactness, and fixed point theorems.)

8. Biswanath Garai – *An Introduction to Metric Space and Functional Analysis*, New Central Book Agency.
9. P. K. Jain and K. Ahmad – *Metric Spaces*, Narosa Publishing House.
10. S. Kumaresan – *Topology of Metric Spaces*, Narosa Publishing House.
11. B. S. Tyagi – *Real Analysis*, Krishna Prakashan Media.

Paper Name: Practical based on DSC1-10 (Metric Spaces)	**Course Code:**
Paper Number: DSC1-10(P)	**Credits: 02**

Course Objectives: To learn about to

1. Develop the ability to compute and verify limits of functions and solve numerical problems related to limits on the real line and in metric spaces.
2. Acquire practical understanding of metric spaces and their properties, including computation of distances, open balls, and examples of metric spaces.
3. Apply definitions to verify continuity, open sets, closed sets, boundedness, and totally bounded sets through numerical examples.
4. Solve problems involving complete metric spaces, Picard fixed point theorem, compactness, finite intersection property, and Heine–Borel property.

Expt. No.	**Title**	**Hours**
1	Numerical Problems based on limit of a function	4
2	Numerical Problems based on metric spaces	4
3	Numerical Problems based on open balls.	4
4	Numerical Problems based on function continuous on metric spaces.	4
5	Numerical Problems based on open and closed sets.	4
6	Numerical Problems based on Bounded sets and totally bounded sets.	4
7	Numerical Problems based on complete metric space-I	4
8	Numerical Problems based on complete metric space-II	4
9	Numerical Problems based on Picard fixed point theorem.	4
10	Numerical Problems based on compactness-I	4
11	Numerical Problems based on compactness-II	4
12	Numerical Problems based on FIP and HBP	4
13	Revision on expts-1 – 3	4
14	Revision on expts-4 – 6	4
15	Revision on expts-7 – 10	4

Course Outcomes:

After successful completion of the practical course, students will be able to:

1. Solve numerical problems related to limits of functions and metric spaces, including the use of distance functions and properties of limits.
2. Construct and analyze open balls, open sets, closed sets, and continuous functions in metric spaces through practical problem solving.
3. Examine bounded sets, totally bounded sets, Cauchy sequences, and completeness of metric spaces using numerical examples.
4. Apply theoretical results such as Picard fixed point theorem, compactness, Heine–Borel property, and finite intersection property to solve practical problems.

Paper Name: Numerical Analysis	**Course Code:**
Paper Number: DSC1-11	**Credits: 03**

Course Objectives: To learn about to

1. To understand the concept of finite differences and study the relations between different difference operators.
2. To learn interpolation techniques such as Newton's forward and backward interpolation, Gauss interpolation, Stirling's formula, and Lagrange interpolation for estimating unknown values.
3. To develop numerical methods for differentiation and integration, including quadrature formulas such as the Trapezoidal rule and Simpson's rules.
4. To study difference equations, including the formation of difference equations and methods for finding complementary functions and particular solution.

Unit	**Content**	**Hours**
I	**Finite Differences** 1.1 Introduction 1.2 Finite differences, 1.3 Differences of Polynomial 1.4 Relation between the operators	15
II	**Interpolation** 2.1 Introduction 2.2 Newton's forward interpolation formula 2.3 Newton's backward interpolation formula 2.4 Central difference interpolation formula 2.5 Gauss's forward interpolation formula 2.6 Gauss's backward interpolation formula 2.7 Stirling's formula 2.8 Interpolation with unequal Intervals 2.9 Lagrange's Interpolation Formula	15
III	**Numerical Differentiation and Integration**	15

	3.1 Numerical differentiation 3.2 Formula for derivatives 3.3 Maxima and minima of a tabulated function 3.4 Numerical Integration 3.5 Quadrature formulae (Trapezoidal rule, Simpson's 1/3 Rule and Simpson's 3/8 th rule)	

Course Outcomes:

After successful completion of the practical course, students will be able to:

1. Students will be able to understand finite differences and the relations between difference operators and apply them to polynomial functions.
2. Students will be able to apply interpolation techniques such as Newton's forward and backward formulas, Gauss formulas, Stirling's formula, and Lagrange interpolation to estimate unknown values.
3. Students will be able to use numerical methods for differentiation and integration, including Trapezoidal rule and Simpson's rules.
4. Students will be able to form and solve linear difference equations, including finding complementary functions and particular integrals.

Recommended Book:

Numerical Methods in Engineering & Science with Programs in C and C++

Nineth Edition by B.S. Grewal Khanna Publishers New Delhi.

Chapter – 6: (Finite differences) Art. 1, 2, 3, 7

Chapter – 7: (Interpolation) : Art 1, 2, 3, 4, 5, 6, 7, 11, 12

Chapter – 8: (Numerical Differentiation and Integration) Art. 1, 2, 3, 4, 5(except IV and V)

Reference Books:

1. Numerical Analysis and Programming in C by Pundir and Pundir (Pragati Prakashan)
2. Numerical Analysis by P. Kandasamy , K. Thilagavathy, K Gunavathi , S, Chand Publications
3. Introductory Methods of Numerical Analysis by S.S. Sastry and by PHI
4. Numerical Analysis Richard L. Burden and J. Douglas Faires
5. Finite Differences and Numerical Analysis H.C. Saxena
6. An Introduction to Numerical Analysis Kendall E. Atkinson
7. Applied Numerical Analysis Curtis F. Gerald and Patrick O. Wheatley
8. Introductory Methods of Numerical Analysis B.S. Grewal
9. A Friendly Introduction to Numerical Analysis Brian Bradie
10. Numerical Methods E. Balagurusamy

Paper Name: Practical based on DSC1-11(Numerical Analysis)	**Course Code:**
Paper Number: DSC1-11(P)	**Credits: 02**

Course Objectives: To learn about to:

1. To understand the concept of finite differences and study the relations between different difference operators.
2. To learn interpolation techniques such as Newton's forward and backward interpolation, Gauss interpolation, Stirling's formula, and Lagrange interpolation for estimating unknown values.
3. To develop numerical methods for differentiation and integration, including quadrature formulas such as the Trapezoidal rule and Simpson's rules.
4. To study difference equations, including the formation of difference equations and methods for finding complementary functions and particular solutions.

Expt. No.	Title	Hours
1	Numerical problems based on Relation between operators	4
2	Numerical problems based on Differences of a Polynomial	4
3	Numerical problems based on Newton's Forwards difference Formula	4
4	Numerical problems based on Newton's Backward difference Formula	4
5	Numerical problems based on Gauss's Forward difference Formula	4
6	Numerical problems based on Gauss's Backword difference Formula	4
7	Numerical problems based on Lagrange's interpolation formula –I	4
8	Numerical problems based on Lagrange's interpolation formula –II	
9	Numerical problems based on Numerical Differentiation	4
10	Numerical problems based on Trapezoidal rule	4
11	Numerical problems based on , Simpson's (1/3)rd Rule	4
12	Numerical problems based on Simpson's (3/8)th rule.	4
13	Revision on expts-1 – 3	4
14	Revision on expts-4 – 6	4
15	Revision on expts-7 – 10	4

Course Outcomes: After successful completion of the practical course, students will be able to:

1. Students will be able to understand finite differences and the relations between difference operators and apply them to polynomial functions.
2. Students will be able to apply interpolation techniques such as Newton's forward and backward formulas, Gauss formulas, Stirling's formula, and Lagrange interpolation to estimate unknown values.
3. Students will be able to use numerical methods for differentiation and integration, including Trapezoidal rule and Simpson's rules.
4. Students will be able to form and solve linear difference equations, including finding complementary functions and particular integrals.

Paper Name: Integral Calculus	Course Code:
Paper Number: DSC1-12	Credits: 03

Course Objectives: To learn about to:

1. To understand the concept of improper integrals and study the conditions for their convergence and divergence using different convergence tests.
2. To develop the ability to apply comparison tests, Cauchy's test, Abel's test, and Dirichlet's test to determine the convergence of improper integrals.
3. To study Beta and Gamma functions, their properties, transformations, and the relationship between them.
4. To learn multiple integrals and their applications, including evaluation of double integrals

Unit	Content	Hours
I	**A. Improper Integrals-I** Convergence of Improper integrals of the first kind, Test of convergence of a (Positive integrands), Necessary and sufficient condition for the convergence of improper integrals, Comparison of two integrals, A practical comparison test, Useful comparison integrals, Two useful tests, f(x) not necessarily positive general test for convergence, Absolute and conditionally convergence,	7
	B. Improper Integrals-II Convergence of improper integrals of the second kind, Convergence at infinity (Integrand being positive), Comparison of two integrals, A useful comparison integrals, General test (for convergence at infinity and f(x) may be positive or negative), Cauchy's test for convergence, Absolute and conditionally convergence of improper integrals of second kind, Test for the absolute convergence of the integral of product, Abel's test, Dirichlet's test.	8
II	**Beta and Gamma function:** Definition, Properties, Transformations of Gamma function and Beta function and relation between them, some important deductions, Duplication formula.	15
III	**Multiple integrals:** Double Integrals, Cartesian and polar, Applications of Double Integration (Area of regions and Volume of a Solid only), Change of order of integration, Change of Variables, applications to area and volume	15

Course Outcomes: After successful completion of this course, students will be able to:

1. Students will be able to understand and analyze improper integrals and determine their convergence or divergence using different convergence tests.
2. Students will be able to apply comparison tests, Cauchy's test, Abel's test, and Dirichlet's test to study absolute and conditional convergence of integrals.
3. Students will be able to understand Beta and Gamma functions, their properties, transformations, and the relationship between them, and solve related problems.

4. Students will be able to evaluate multiple integrals (double integrals) and apply them to find area of regions, volume of solids, and perform change of order and change of variables.

Recommended Book:

Integral Calculus by Shanti Narayan and P.K. Mittal S.Chand publication Revised Edition

Scope of syllabus:

Unit 1: 16.1 to 16.18
Unit 2: 7.1, 7.2, 7.3, 7.4, 7.5
Unit 3: 12.2, 12.3, 12.4, 12.5

Reference Books:

1. Differential and Integral Calculus — Gorakh Prasad
2. Calculus and Analytic Geometry — George B. Thomas and Ross L. Finney
3. Calculus (Early Transcendentals) — James Stewart
4. Calculus — Howard Anton, Irl Bivens and Stephen Davis
5. Advanced Calculus (Schaum's Outline Series) — Murray R. Spiegel
6. Calculus — P. R. Vittal
7. Mathematics for B.Sc.. Students (Integral Calculus) — Shanti Narayan
8. Calculus Volume I & II — Tom M. Apostol
9. Advanced Calculus — David V. Widder
10. A Course of Mathematical Analysis – Shanti Narayan

Paper Name: Practical based on DSC1-12 (Integral Calculus)	**Course Code:**
Paper Number: DSC1-12(P)	**Credits: 02**

Course Objectives: To learn about to:

1. To understand the concept of improper integrals and study the conditions for their convergence and divergence using different convergence tests.
2. To develop the ability to apply comparison tests, Cauchy's test, Abel's test, and Dirichlet's test to determine the convergence of improper integrals.
3. To study Beta and Gamma functions, their properties, transformations, and the relationship between them.
4. To learn multiple integrals and their applications, including evaluation of double integrals, change of order of integration, change of variables, and applications to area and volume.

Expt. No.	Title	Hours
1	Numerical problems based on Convergence of Improper integrals	4
2	Numerical problems based on, Comparison of two integrals	4
3	Numerical problems based on, Absolute and	4

	conditionally convergence	
4	Numerical problems based on Abel's test	4
5	Numerical problems based on Dirichlet's test	4
6	Numerical problems based on Gamma function	4
7	Numerical problems based on Beta function	4
8	Numerical problems based on Duplication formula	4
9	Numerical problems based on Double Integrals	4
10	Numerical problems based on Cartesian and polar	4
11	Numerical problems based on Change of order of integration	4
12	Numerical problems based on Change of Variables.	4
13	Revision on expts-1 – 3	4
14	Revision on expts-4 – 6	4
15	Revision on expts-7 – 10	4

Course Outcomes:

After successful completion of this course, students will be able to:

1. Students will be able to understand and analyze improper integrals and determine their convergence or divergence using different convergence tests.
2. Students will be able to apply comparison tests, Cauchy's test, Abel's test, and Dirichlet's test to study absolute and conditional convergence of integrals.
3. Students will be able to understand Beta and Gamma functions, their properties, transformations, and the relationship between them, and solve related problems
4. Students will be able to evaluate multiple integrals (double integrals) and apply them to find area of regions, volume of solids, and perform change of order and change of variables.

Paper Name: - Fourier Analysis	**Course Code:**
Paper Number: DSE1-3	**Credits: 02**

Course Objectives: To learn about to

1. Develop a rigorous understanding or the Fourier transforms finite and infinite transform
2. understand sine and cosine transform
3. Study concept and elementary result of Fourier transform

4. Study Boundary values problem.

Unit	Content	Hours
I	**The infinite Fourier Transform** Infinite Fourier sine transform of f(x) Infinite Fourier cosine transorm of f(x) Infinite Fourier Transform of f(x) Relation between Fourier transform and Laplace Transform	8
II	**The finite Fourier Transform and Fourier Integral** Finite Fourier sine transform Finite Fourier cosine transform Fourier integral theorem Solved Problems	8
III	**Fourier Series and Boundary Value Problem** Periodic Function Trigonometric Series Fourier Series and Fourier Coefficient theorem A Fourier theorem Even and Odd Function let $f(x) = \frac{a_0}{2} + \sum_0^\infty (a_n cosnx + b_n sinnx)$ Half range Series Change of Interval Change of Period	14

Course Outcomes:

After successful completion of this course, students will be able to:

1. Define key term related to Transformer and boundary value problem
2. Analyze the properties of food transforms
3. Construct clear and regress mathematical concept and proof using logical reasoning
4. Evaluate the usefulness of Fourier Transformer in solving specific type of problem in engineering physics and applied mathematics critically assess the accuracy and efficiency of using numerical method for completing full transformer

Recommended Book:

Integral Transforms - Goyal & Gupta (Pragati prakashan Meerut)

Scope of syllabus

Unit-1: Chapter 2, Part-I: 2.1, 2.2, 2.3. 2.4

Unit-2: Chapter 2, Part-II: 2.1

Unit-3: Chapter 8, 8.0, 8.1, 8.2, 8.3, 8.5, 8.6, 8.7, 8.8, 8.9, 8.10

Reference Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics (8th Edition), Willey Publication

2. L. Debnath, Integral transfrom and their Application, CRC.press, New York London
3. Wiley & Barrett Advanced Engineering Mathematics McGraw Hill Publication
4. H.K Dass, Alvanced Engineering Mathematics, S. Chand Publication
5. Ravish R. Singh and mukul Bhatt, Advanced Engineering Mathematic) (4thEdition) MeGraw Hill publication, 2018

Paper Name: Practical based on DSE1-3 (FA)	**Course Code:**
Paper Number: DSE1-3(P)	**Credits: 01**

Course Objectives: To learn about to:

1. Understand sine & cosine transform.
2. Study the concept and elementary results of Fourier transform.
3. Study Boundary Value Problems.

Expt. No.	Title	Hours
1	Numerical problems based on the infinite Fourier sine transform	4
2	Numerical problems based on the infinite Fourier cosine transform	4
3	Numerical problems based on the finite Fourier sine transform	4
4	Numerical problems based on the finite Fourier cosine transform	4
5	Numerical problem based on Fourier transform	4
6	Numerical problem based on Even & Odd functions	4
7	Numerical problem based on Half-range series	4

Course Outcomes:

After successful completion of this course, students will be able to:

1. Analyze the properties of Fourier transforms.
2. Construct clear and rigorous mathematical concepts using logical reasoning.
3. Evaluate the usefulness of Fourier transforms in solving specific types of problems in engineering, physics, and applied mathematics; critically address the accuracy and efficiency of using numerical methods for computing Fourier transforms.
4. Identify the difference between even & odd functions.

Paper Name: Hands on Training based on DSE1-3 (FA)	**Course Code:**
Paper Number: VSC4	**Credits: 02**

Course Objectives: To learn about to:

1. Apply theoretical concepts of fourier Transform to solve practical problems
2. Solve finite and infinite fourier Transform using analytic technique and verify result through problem solving approaches
3. Construct Clear and rigorous mathematic proof using Standard analytical techniques
4. Apply analytical concept to solve applied problem and prepare for higher Studies in pure and applied Mathematics

Expt. No.	Title	Hours

1	Numerical problem based on the infinite Fourier sine transform	4
2	Numerical problem based on the infinite Fourier cosine transform	4
3	Numerical problem based on the finite Fourier sine transform	4
4	Numerical problem based on the finite Fourier cosine transform	4
5	Numerical problem based on Fourier transform	4
6	Numerical problem based on Even and odd function	4
7	Numerical problem based on $f(x) = \frac{a_0}{2} + \sum_0^\infty (a_n cosnx + b_n sinnx)$	4
8	Numerical problem based on Half-range Serier	4
9	Numerical problem based on charge of interval	4
10	Numerical problem based on Change of period	4

Course outcome:

After successful competition of the course student will be able to

1. Analyze the properties of Fourier transforms
2. Construct clear and rigorous mathematical concept using logical reasoning
3. Evaluate the usefulness of Fourier Transform in solving specific type of problem in engineering physics and applied mathematics critically assess the accuracy and efficiencyof using Numerical Method for computing fourier transform
4. Identify the difference between Even and Odd function

Paper Name: Graph Theory	**Course Code:**
Paper Number: DSE1-4	**Credits: 02**

Course Objectives: To learn about to:

1. To understand the fundamental concepts of Graph Theory including types of graphs, vertex degree, bipartite graphs, and graph isomorphism.
2. To study various graph operations and properties such as union, intersection, complement, product, paths, cycles, connectivity, cut-vertices, bridges, and matrix representations of graphs.
3. To learn the structure and properties of trees, including rooted trees, spanning trees, minimal spanning trees, tree traversal techniques, and prefix/postfix expressions.
4. To understand different number systems (Binary, Decimal, Octal, and Hexadecimal) and perform conversions between these systems used in computer science.

Unit	Content	Hours
I	**A. Graph Theory:** Graphs–undirected and directed, simple graphs, multigraphs, degree of vertex, indegree and outdegree of vertex, Types: Null graph, Complete graph, regular graph, platonic, cycles, wheels, Bipartite, complete bipartite, subgraphs, and isomorphic Graphs. **B. Operations on Graph:** Union , Intersection, Sum, Ring sum, Complements, product, composition	15

	and fusion, Paths, Cycles, Cut -vertex, cut set, Bridge, Connectedness, Matrix representation, Adjacency matrix, Incidence matrix, Planner graphs, Eulerian and Hamiltonian graphs, Euler's formula.	
II	**A. Trees:** Trees and their Properties, Rooted trees, Spanning trees, Construction of spanning trees, weighted graphs, Minimal Spanning trees, Tree traversal, Prefix and Postfix notation **B. Number Systems:** Binary, Decimal, Octal and Hexadecimal number system and Conversions between these systems.	15

Course Outcomes:

After successful completion of this course, students will be able to:

1. Students will be able to define and recall basic concepts of Graph Theory, including types of graphs, degree of vertices, bipartite graphs, and basic terminology.
2. Students will be able to explain and classify different graph structures and operations such as union, intersection, complement, paths, cycles, connectivity, and matrix representations of graphs.
3. Students will be able to apply graph and tree concepts to solve problems involving spanning trees, minimal spanning trees, tree traversals, and prefix–postfix expressions.
4. Students will be able to analyze and perform conversions among different number systems (Binary, Decimal, Octal, and Hexadecimal) and examine properties of graphs such as Eulerian and Hamiltonian graphs.

Recommended Book:

A text book of Discrete Mathematics, Swapan Kumar Sarkar, S. Chand & Company

Scope of syllabus: Recommended Books (Scope of syllabus):

[I] A text book of Discrete Mathematics by Swapan Kumar Sarkar (S.Chand Co. 1st edition 2003)

Chapter – 13: 13.1 to 13.12

Chapter – 14: 14.1 to 14.4

[II] Essential Computer Mathematics by Seymour Lipshutz, Schaum's outline series

Chapter - 1: 1.1 to 1.3

Chapter - 2: 2.1 to 2.4

Reference Books:

1. Discrete Mathematics and Its Applications, Kenneth H. Rosen, McGraw-Hill Education, 2012

2. Introduction to Graph Theory, Douglas B. West, Prentice Hall, 2001
3. Graph Theory with Applications, J. A. Bondy & U. S. R. Murty, Elsevier / North Holland, 1976
4. Graph Theory, Reinhard Diestel, Springer, 2017
5. Discrete Mathematics, Richard Johnsonbaugh, Pearson Education, 2017
6. A Textbook of Graph Theory, R. Balakrishnan & K. Ranganathan, Springer, 2012
7. Discrete Mathematics with Graph Theory, Edgar G. Goodaire & Michael M. Parmenter, Pearson, 2005
8. Elements of Discrete Mathematics, C. L. Liu & D. P. Mohapatra, McGraw-Hill, 2008
9. Applied Discrete Structures for Computer Science, Alan Doerr & Kenneth Levasseur, Pearson, 2003
10. Discrete Mathematics, Richard Johnsonbaugh, Pearson Education, 2017

Paper Name: Practical based on DSE1-4(Graph Theory)	**Course Code:**
Paper Number: DSE1-4(P)	**Credits: 01**

Course Objectives: To learn about to:

1. Understand the basic concepts and types of graphs such as undirected graphs, directed graphs, simple graphs, multigraphs, and pseudographs.
2. Apply graph algorithms such as Dijkstra's Algorithm to determine the shortest path in a weighted graph.
3. Analyze graph structures by solving numerical problems **on** graph isomorphism and matrix representation**.**
4. Understand different number systems and perform conversions between binary, octal, hexadecimal, and decimal systems.

Expt. No.	**Title**	**Hours**
1	Numerical problems based on Graphs–undirected and directed, simple graph, Multigraph and Psuedograph	4
2	Numerical problems based on To find the shortest path using Dijkstra's Algorithm	4
3	Numerical problems based on Determining Whether Two Given Graphs Are Isomorphic	4
4	Numerical problems based on Undirected graphs using Adjacency and Incidence Matrices	4
5	Numerical problems based on Directed graphs using Adjacency and Incidence Matrices	4
6	Numerical problems based on Conversion of binary/octal/Hexadecimal to decimal	4

7	Revision on above experiments	4

Course Outcomes: After successful completion of this course, students will be able to:

1. Define and recall the basic terminology of graphs such as simple graphs, multigraphs, pseudographs, directed graphs, and undirected graphs.
2. Explain and represent graphs using adjacency matrices and incidence matrices for both directed and undirected graphs.
3. Apply Dijkstra's Algorithm to determine the shortest path between vertices in a weighted graph.
4. Analyze given graphs to determine whether two graphs are isomorphic using degree sequence and structural comparison.
5. Perform numerical conversions between binary, octal, hexadecimal, and decimal number systems**.**

Paper Name: Hands on Training based on DSE1-4(GT)	**Course Code:**
Paper Number: VSC4	**Credits: 02**

Course Objectives:

To learn about to:

1. To understand the fundamental concepts of graphs including directed graphs, vertex degree, and graph operations such as union, intersection, sum, and ring sum.
2. To develop problem-solving skills using graph traversal algorithms such as Depth-First Search and Breadth-First Search.
3. To study tree structures and traversal techniques including preorder, in order, and post order traversal.
4. To apply graph algorithms for constructing spanning trees and determining minimal spanning trees using Prim's Algorithm and Kruskal's Algorithm.
5. To develop computational skills in solving numerical problems related to Eulerian graphs, Hamiltonian graphs, and number system conversions**.**

Expt. No.	**Title**	**Hours**
1	Numerical problems based on To find the shortest path using Depth-first Search (DFS) Algorithm	4
2	Numerical problems based to determine indegree traversal methods and outdegree of vertices in a directed graph.	4
3	Numerical problems based on Program to perform graph operations such as union, intersection, Sum, Ring Sum of two graphs.	4
4	Numerical problems based on Implementation of tree (Preorder, Inorder, Postorder).	4

5	Numerical problems based on Program to check whether a graph is Eulerian**,** Hamiltonian	4
6	Numerical problems based on To find the shortest path using Breadth First Search (BFS) Algorithm	4
7	Numerical problems based on Construction of spanning tree for a given graph.	4
8	Numerical problems based on Program to find Minimal Spanning Tree using Prim's algorithm**.**	4
9	Numerical problems based on Program to find Minimal Spanning Tree using Kruskal's algorithm**.**	4
10	Numerical problems based on Numerical Problems based on Conversion of decimal to binary/octal/ Hexadecimal.	4

Course Outcomes:

After successful completion of this course, students will be able to:

1. Define and recall basic concepts of graphs including vertex degree, indegree, outdegree, and properties of directed and undirected graphs.
2. Explain graph operations and traversal techniques such as Depth-First Search and Breadth-First Search.
3. Apply algorithms to construct spanning trees and determine minimal spanning trees using Prim's Algorithm and Kruskal's Algorithm.
4. Analyze given graphs to determine whether they are Eulerian or Hamiltonian and perform graph operations such as union, intersection, sum, and ring sum.
5. Perform numerical conversions from decimal number system to binary, octal, and hexadecimal systems**.**

Equivalent Subjects for Old Syllabus

Semester-V

Sr. No.	**Name of the Old Paper**	**Name of the New Paper (As per NEP2020)**
1	Paper-IX : Algebra – II	DSC1-7: Abstract Algebra – II
2	Paper-X : Complex Analysis	DSC1-8: Complex Analysis
3	Paper-XI : Real Analysis	DSC1-9: Real Analysis
4	Paper-XII : Partial Differential Equations (Elective - A)	DSE1-1: Partial Differential Equations
	Paper-XII :Operations Research (Elective - B)	DSE1-2: Operations Research

5	---	VSC3: Hands on Training Related to DSE1-1 OR DSE1-2
6	---	IKS2: Ancient Indian Mathematics

Semester-VI

Sr. No.	Name of the Old Paper	Name of the New Paper (As per NEP 2020)
1	Paper-XIII : Metric Spaces	DSC1-10: Metric Spaces
2	Paper-XIV : Numerical Analysis	DSC1-11: Numerical Analysis
3	Paper-XV :Integral Calculus	DSC1-12: Integral Calculus
4	Paper-XVI :Graph Theory (Elective -A)	DSE1-3: Fourier Analysis
	Paper-XVI : Programming in C (Elective - B)	DSE1-4: Graph Theory
5	---	VSC4: Hands on Training Related to DSE1-3 OR DSE1-4
6	---	Field Projects/Internships/ Apprenticeships/ Community Engagement Projects/On-Job Training