VIVEKANAND COLLEGE, KOLHAPUR
(AN EMPOWERED AUTONOMOUS INSTITUTE)

DEPARTMENT OF MATHEMATICS
Three/Four- Years UG Programme
Department/Subject Specific Core or Major (DSC)

Curriculum, Teaching and Evaluation Structure
for
B.Sc.-III Mathematics

Semester- V & VI

(Implemented from academic year 2025-26 onwards)

Vivekanand College, Kolhapur (An Empowered Autonomous Institute)
Department of Mathematics
B.Sc. III

POs:

- **PO1: Disciplinary Knowledge:** Graduates will gain in-depth understanding in their specific major or discipline, mastering the foundational principles and theories, as well as advanced concepts. Execute strong theoretical and practical understanding developed from the specific programme in the area of work.
- **PO2: Problem-Solving Skills:** Graduates will learn to use their knowledge to identify, analyse, and solve problems related to their field of study Students should progress their vertical mobility.
- **PO3: Analytical Skills:** Graduates will gain the ability to collect, analyse, interpret, and apply data in a variety of contexts. They might also learn to use specialized software or equipment.
- **PO4: Research Skills and Scientific temper:** Depending on the field, graduates might learn how to design and conduct experiments or studies, analyse results, and draw conclusions. They might also learn to review and understand academic literature.
- **PO5: Communication Skills:** Many programs emphasize the ability to communicate effectively, both orally and in writing. Graduates may learn to present complex information clearly and succinctly, write detailed reports, and collaborate effectively with others.
- **PO6: Ethics and Professionalism**: Graduates may learn about the ethical and professional standards in their field, and how to apply them in real-world situations.

B.Sc. III Mathematics

PSOs:

- **PSO1:** Enabling students to develop a positive attitude towards mathematics as an interesting and valuable subject of study.
- **PSO2:** The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.
- **PSO3:** Students should be able to recall basic facts about mathematics and train the students to extract information, formulate and solve problems in systematic and logical manner.
- **PSO4:** Students will learn numerical aptitude applying both qualitative and quantitative knowledge for their further career.
- **PSO5:** This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

VIVEKANAND COLLEGE, KOLHAPUR (AN EMPOWERED AUTONOMOUS INSTITUTE)
Department of Mathematics
Teaching and Evaluation Scheme
Three/Four- Years UG Programme
Department/Subject Specific Core or Major (DSC)
Third Year Semester-V & VI

Sr. No.	Course Abbr.	Course code	Course Name	Teaching Scheme Hours/week		Examination Scheme and Marks				Course Credits
				TH	PR	ESE	CIE	PR	Marks	
Semester-V										
1	DSC-IX	DSC03MAT51	Real Analysis	2	-	40	10	-	50	2
2	DSC-X	DSC03MAT52	Abstract Algebra	2	-	40	10	-	50	2
3	DSC-XI	DSC03MAT53	Partial Differential Equation-I	2	-	40	10	-	50	2
4	MIN-IX	MIN03MAT51	Computational Mathematics	2	-	40	10	-	50	2
5	DSE-I	DSE03MAT51	Relativity	2	-	40	10	-	50	2
		DSE03MAT52	Numerical Methods	2	-	40	10	-	50	2
6	VSC-PR-IV	VSC03MAT59	Introduction to Scilab	-	4	-	-	25	25	2
7	FP	FPR03MAT51	Field Project	-	-			50	50	2
8	DSC-PR-V	DSC03MAT59	DSC Mathematics Lab-5	-	12			75	75	6
9	MIN-PR-V	MIN03MIN59	MIN Mathematics Lab-5	-	4			25	25	2
Semester-V Total				10	20	200	50	175	425	22
Semester-VI										
1	DSC-XII	DSC03MAT61	Metric Space	2	-	40	10	-	50	2
2	DSC-XII	DSC03MAT62	Linear Algebra	2	-	40	10	-	50	2
3	DSC-XIV	DSC03MAT63	Complex Analysis	2	-	40	10	-	50	2
4	MIN-X	MIN03MAT61	Basics of Operation Research	2	-	40	10	-	50	2
5	DSE-II	DSE03MAT61	Tensor	2	-	50	-	-	50	2
		DSE03MAT62	Optimization Techniques	2	-	50	-	-	50	2
6	VSC-PR-V	VSC03MAT69	Scilab for Numerical Methods	-	4	--	-	25	25	2
7	OJT	OJT03MAT61	On Job Training		-			50	50	2
8	DSC-PR-VI	DSC03MAT69	DSC Mathematics Lab-6	-	12	-	-	75	75	6
9	MIN-PR-VI	MIN03MAT69	MIN Mathematics Lab -6		4			25	25	2
Semester-VI Total				10	20	200	50	175	425	22

B. Sc. Part – III Semester -V Mathematics
DSC-IX : DSC03MAT51 : Real Analysis
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
CO2: use the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.
CO3: understand some of the families and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.
CO4: solve Riemann integral and improper integral.

UNIT	Title of unit & Contents	Hours Allotted
1	**SEQUENCES OF REAL NUMBERS:** Upper bound, Lower bound, Least upper bound, Greatest lower bound, Definition of sequence and subsequence, Limit of a sequence, Convergent sequence, Divergent sequence, Bounded sequence, Monotone sequence, Limit superior and limit inferior, Cauchy sequences.	08
2	**SERIES OF REAL NUMBERS:** Convergence and Divergence, Series with non-negative terms, Alternating series, Conditional convergence and absolute convergence, Rearrangements of series, Tests of absolute convergence, Series whose terms form a non-increasing sequence.	08
3	**RIEMANN INTEGRAL:** Riemann integrability and integral of a bounded function over finite domain, Darboux's theorem (statement only), another equivalent definition of integrability and integral, Conditions for integrability, Particular classes of bounded integrable functions, Properties of integrable functions.	07
4	**IMPROPER INTEGRAL:** Definitions of Improper integral, Test for convergence at 'a'. Positive integrand f(x), not necessarily positive. General test for convergence, Convergence at ∞, the integrand being not necessarily positive: General test for convergence, Absolute convergence, Tests for conditional convergence.	07

Recommended Books:
1. Richard R. Goldberg, Method of Real Analysis, Oxford and IBH publishing CO. PVT.LTD
2. Shanti Narayan and P. K. Mitthal, A Course of Mathematical Analysis, S. Chand Publication

Reference Books:
1. Tom M. Apostol, Mathematical Analysis (Second Edition) Narosa Publishing House, New Delhi
2. H.L. Royden, Real Analysis (Fourth Edition) Pearson India Education Services Pvt. Ltd.

B. Sc. Part – III Semester -V Mathematics
DSC-X : DSC03MAT52 : Abstract Algebra
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.
CO2: explain the significance of the notion of cosets, normal subgroups, and factor groups.
CO3: the fundamental concept of Rings, Fields, subrings, integral domains and the corresponding Homomorphism.
CO4: apply fundamental theorem, Isomorphism theorems of groups to prove these theorems for Ring.

UNIT	Title of unit & Contents	Hours Allotted
1	**GROUPS:** Binary Compositions, Permutations (Definition and examples), Cyclic Permutations, Cycles of a Permutation, Disjoint Permutations Even permutation, odd permutation, Groups - Abelian groups (definition and examples), Subgroups, Centre of group, Normaliser of subgroup, Cosets, Cyclic Groups, Euler's theorem and Fermat's theorem	08
2	**NORMAL SUBGROUPS, HOMOMORPHISM:** Normal Subgroups, Quotient Groups, Homomorphisms, Isomorphisms, Kernel, Fundamental theorems of homomorphism, conjugate elements	07
3	**RINGS:** Rings, zero divisors, Integral domains, Field, Subrings, Characteristic of a Ring, Idempotent element, nilpotent element, Product of Rings, Ideals, Sum of Ideals, Product of Ideals, Simple rings	08
4	**HOMOMORPHISMS IN RINGS:** Quotient Rings, Homomorphisms, kernel, fundamental theorems of ring homomorphism, Embedding of Rings(statements), Maximal Ideal, Prime ideals	07

Recommended Book:
1. J.B. Fraleigh and N. E. Brand, A course in abstract algebra, 8th edition Pearson, Narosa Publishing House
2. V. K. Khanna and S. K. Bhambri, A course in abstract algebra, 5th edition, Vikas publishing house Pvt. Ltd.

Reference book:
1. Joseph A. Gallian, Contemporary Abstract Algebra (Fourth Edition) Narosa Publishing House.

B. Sc. Part – III Semester -V Mathematics
DSC-XI : DSC03MAT53 : Partial Differential Equation-I
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: classify first order partial differential equation.
CO2: understand the concept of formation of partial differential equation.
CO3: understand the methods of solving non-linear P.D.E of order one.
CO4: apply method of finding the C.F. of linear homogeneous coefficient and P.I of homogeneous P.D.E.

Units	Title of unit & Contents	Hours Allotted
1	**LINEAR PARTIAL DIFFERENTIAL EQUATION OF ORDER ONE:** Definition, Order of a P.D.E., Degree of a P.D.E., Linear and non-linear P.D.E., Notations, Classification of first order P.D.E., Origin of P.D.E., Derivation of P.D.E., by the elimination of arbitrary constants, examples, Derivation of P.D.E., by elimination of arbitrary functions. examples, Cauchy's problem for first order equations, Lagrange's method of solving Pp + Qq = R,	**04**
2.	**NON- LINEAR PARTIAL DIFFERENTIAL EQUATION OF ORDER ONE:-** Complete integral, particular integral, singular integral and general integral, Geometrical interpretation of integrals of f(x, y, z, p, q) = 0, Method of getting singular integral directly from the P.D.E. of first order, Charpit's method and its particular form.	**08**
3	**HOMOGENEOUS LINEAR PARTIAL DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS:** Homogeneous and non-homogeneous linear P.D.E. with constant coefficients, Solution of a homogeneous linear P.D.E. with constant, Method of finding the complementary function (C.F.) of linear homogeneous coefficients, P.D.E. with constant coefficients Working rule for finding C.F. of linear P.D.E. with constant coefficients, Alternative working rule for finding C.F. examples, Particular integral (P.I.) of homogeneous P.D.E., Short methods of finding P.I.	**09**
4	**NON-HOMOGENEOUS LINEAR PARTIAL DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS:** Reducible and irreducible linear differential operators and linear P.D.E. with constant coefficients Theorem. If the operator F(D,D') is reducible, then the order in which the linear factors occur is unimportant, Determination of complementary function (C.F) of a reducible non-homogeneous linear P.D.E. with constant coefficients, Working rule for finding C.F. of reducible non-homogeneous linear P.D.E. with constant coefficients and examples, Method of finding C.F. of irreducible linear P.D.E. with constant coefficients and examples, General solution of non-homogeneous linear P.D.E. with constant coefficients, Particular integral (PI) of non-homogeneous linear P.D.E., Determination of P.I. of non-homogeneous linear P.D.E. (reducible or irreducible) examples	**09**

Recommended books:
1. Dr. M. D. Raisinghania, Ordinary and Partial Differential Equation, S.Chand

Reference book:-
1. IAN N. SNEDDON, Elements of partial differential equation, Dover publication.
2. Daniel A. Murray Introductory Course in Differential Equations Khosla Publishing House

B. Sc. Part – III Semester -V Mathematics
MIN-IX : MIN03MAT51 : Computational Mathematics
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course outcomes:
On completion of the course, the students will be able to:
CO1: use interpolation methods to solve problems of equal and unequal intervals.
CO2: understand numerical differentiation based on interpolation polynomial.
CO3: learn numerical methods to calculate numerical integration by using Newton-Cotes formula.
CO4: solve of first order ordinary differential equation with numerical methods.

UNIT	Title of unit & Contents	Hours Allotted
1	**NUMERICAL INTERPOLATION: (for unequal interval)** Introduction, Lagrangian interpolating polynomial (formula only), examples, Divided difference interpolation: Newton's divided differences, divided difference table, examples finding divided (differences of given data), Newton's divided difference form of interpolating polynomial, examples	08
2	**NUMERICAL INTERPOLATION: (for equal interval)** Forward interpolation: Newton's forward differences, forward difference table. Newton's forward form of interpolating polynomial (formula only), examples. Backward interpolation: Newton's backward differences, backward difference table, Newton's backward form of interpolating polynomial (formula only), examples	09
3	**NUMERICAL DIFFERENTIATION AND INTGRATION:** Numerical differentiation based on interpolation polynomial. Numerical integration: Newton-Cotes formula, Basic Trapezoidal rule (excluding the computation of error term), composite Trapezoidal rule, examples, Basic Simpson's 1/3rd rule (excluding the computation of error term), composite Simpson's 1/3rd rule, examples, Basic Simpson's 3/8th rule (excluding the computation of error term), composite Simpson's 3/8th rule, examples.	09
4	**SOLUTION OF FIRST ORDER ORDINARY DIFFERENTIAL EQUATION:** Euler's Methods, Modified Euler's Methods, Examples, Second order Runge-Kutta method (formula only), examples, Fourth order Runge-Kutta method (formula only), examples	08

Recommended Books:
1.Devi Prasad, An Introduction to Numerical Analysis (Third Edition), Narosa Publishing House**.**

Reference books:
1. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India.
2. J. H. Mathews, Numerical Methods for Mathematics, Science and Engineering, Prentice Hall of India.
3. K. Sankara Rao, Numerical Methods for Scientists and Engineers, Prentice Hall of India.

B. Sc. Part – III Semester -V Mathematics
DSE-I : DSE03MAT51 : Relativity
Theory: 30 hrs.
Marks-50 (Credits: 02)

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

CO1: learn about conservation laws in Newtonian Mechanics.

CO2: understand Einstein's principle of relativity.

CO3: use of transformation of the Lorentz contraction factor the Transformations for the acceleration of a particle.

CO4: learn about relativistic mechanics.

UNIT	Title of unit & Contents	Hours Allotted
1	**CLASSICAL THEORY OF RELATIVITY** Review of Newtonian Mechanics. Inertial system. Event. Galilean Transformations. Newtonian Relativity. Conservation laws in Newtonian Mechanics. Ether. Maxwell's electromagnetic theory. The Michelson – Morley experiment. Fitzgerald and Lorentz Contraction hypothesis.	08
2	**LORENTZ TRANSFORMATIONS** Einstein's Special Relativity Theory. Einstein's principle of relativity. Principle of constancy of light speed. Lorentz Transformations. Consequences of Lorentz Transformation Lorentz – Fitzgearld length contraction Time dilation Clock paradox or twin paradox. Simultaneity Geometrical Interpretation of LT. Group property of Lorentz Transformations and examples	09
3	**RELATIVISTIC KINEMATICS:** Introduction. Transformation of particle velocity. Relativistic addition law for velocities. Transformation of the Lorentz contraction factor $(1-\frac{V^2}{C^2})^{\frac{1}{2}}$ The Transformations for the acceleration of a particle.	09
4	**RELATIVISTIC MECHANICS :** Introduction (Mass and Momentum). The mass of a moving particle $m=\frac{m_0}{\sqrt{1-\frac{u^2}{C^2}}}$ Relativistic expression for Force. Transverse and Longitudinal mass of the particle. Mass energy equivalence $E = mc^2$. Transformation equations for mass. Transformation equations for momentum and energy. Minkowski Space (Four Dimensional Continuum). Time-like, Space- like, Light – like (null) intervals. Events occurring at the same point and the same time. Theorem: There exists an inertial system S′ in which the two events occur at one and the same point if the interval between two events is timelike. Corollary: Two events which are separated by a timelike interval cannot occur simultaneously in any inertial system.	08

Recommended Books:

1. T. M. Karade, K. S. Adhav and Maya S. Bendre, Sonu Nilu, Special Relativity, 5,Bandu Soni Layout , Gayatri Road, Parsodi, Nagpur, 440022.
2. J.K.Goyal , K.P.Gupta , Theory of Relativity (Special and General), Krishna Prakashan Media (P) Ltd., Meerut., 2006.

Reference books:

1. Einstein A. , The meaning of Relativity, Oxford Book Company, 1965.

B. Sc. Part – III Semester -V Mathematics
DSE-I : DSE03MAT52 : Numerical Methods
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: use interpolation methods to solve problems of equal and unequal intervals.
CO2: understand numerical differentiation based on interpolation polynomial.
CO3: learn numerical methods to calculate numerical integration by using Newton-Cotes formula.
CO4: solve of first order ordinary differential equation with numerical methods.

UNIT	Title of unit & Contents	Hours Allotted
1	**NUMERICAL INTERPOLATION: (for unequal interval)** Introduction, Lagrangian interpolating polynomial (formula only), examples, Divided difference interpolation: Newton's divided differences, divided difference table, examples finding divided (differences of given data), Newton's divided difference form of interpolating polynomial, examples	08
2	**NUMERICAL INTERPOLATION: (for equal interval)** Forward interpolation: Newton's forward differences, forward difference table. Newton's forward form of interpolating polynomial (formula only), examples. Backward interpolation: Newton's backward differences, backward difference table, Newton's backward form of interpolating polynomial (formula only), examples	09
3	**NUMERICAL DIFFERENTIATION AND INTGRATION:** Numerical differentiation based on interpolation polynomial. Numerical integration: Newton-Cotes formula, Basic Trapezoidal rule (excluding the computation of error term), composite Trapezoidal rule, examples, Basic Simpson's 1/3rd rule (excluding the computation of error term), composite Simpson's 1/3rd rule, examples, Basic Simpson's 3/8th rule (excluding the computation of error term), composite Simpson's 3/8th rule, examples.	09
4	**SOLUTION OF FIRST ORDER ORDINARY DIFFERENTIAL EQUATION:** Euler's Methods, Modified Euler's Methods, Examples, Second order Runge-Kutta method (formula only), examples, Fourth order Runge-Kutta method (formula only), examples	08

Recommended Books:
1.Devi Prasad, An Introduction to Numerical Analysis (Third Edition), Narosa Publishing House**.**

Reference books:
1. S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India.
2. J. H. Mathews, Numerical Methods for Mathematics, Science and Engineering, Prentice Hall of India.
3. K. Sankara Rao, Numerical Methods for Scientists and Engineers, Prentice Hall of India.

B. Sc. Part – III Semester -V Mathematics
VSC-PR-IV : VSC03MAT59: Introduction to Scilab
Practical 04 Lectures of 60 minutes per week per batch
Marks-25 (Credits: 02)

Practicals:

1. Introduction to Scilab: Overview of Scilab and its applications in mathematics. Installing Scilab, Scilab environment: Console window, Command History window, Variable Browser window, File Browser window, SciNotes window, Graphics window. Getting Help in Scilab. Use of Scilab as a calculator.
2. Basics of Scilab: Introduction, Character Set. Data types: Integer data type, Real data type, Complex data type, Boolean data type, String data type. Constants and Variables in Scilab, Operators: Arithmetic, Relational, Logical. Hierarchy of Operations, Scilab Expressions, Built-in Functions.
3. Polynomial: Polynomial creation, Polynomial evaluation, Roots of a Polynomial, Polynomial Arithmetic Operations, Polynomial Differentiation and Integration.
4. Basic Elements of Scilab as a Programming Language: Scilab Editor, Scilab Keywords, Predefined Variables, Input and Output Statements, Assignment statements, Simple Programs based on elementary operators.
5. Conditional structure: if-else, if-elseif-else, select-case, Simple Programs based on conditional structure.
6. Looping structure: for loop, while loop, break and continue statement, Simple Programs based on Looping structure.
7. Vectors and Matrices: Row matrix, column matrix, general matrix, operation on matrix addition, subtraction, product.
8. Advanced matrix operations: Matrix functions: eye(), zero(), ones(),
9. empty matrix, element-wise operation, determinant, inverse, trace of matrix & eigen values and vectors of matrix.
10. Functions: Defining custom functions and Programs based on it.
11. Plotting graph: Creating two dimensional graphs of simple functions.

Recommended Book:

1. Chetana Jain, **Advanced Programming in Scilab**, Alpha Science International Ltd (2020).

Reference Books:-

1. Claude Gomez (Editor), C. Bunks (Contributor), J.-P. Chancelier (Contributor), F. Delebecque (Contributor), M. Goursat (Contributor), R. Nikoukhah (Contributor), S. Steer (Contributor), Engineering and Scientific Computing with Scilab 1999th Edition
2. Sandeep Nagar, Introduction to Scilab, For Engineers and Scientists Book.
3. Official Scilab Documentation: www.scilab.org.

B. Sc. Part – III Semester -V Mathematics
FP: FPR03MAT51: Field Project
Practical 04 Lectures of 60 minutes per week per batch
Marks-50 (Credits: 02)

Guidelines

For detailed guidelines follow given link:
https://www.vivekanandcollege.ac.in/uploads/nep/Policies/Policy-Field%20Projects%20VCK.pdf

B. Sc. Part – III Semester -V Mathematics
DSC-PR-V DSC03MAT59 : DSC Mathematics Lab-5
Practical 12 Lectures of 60 minutes per week per batch
Credits: 06
Marks-75 [17(A)+17(B)+17(C)+17(D)+05(J)+02(O)]

Practicals:

A. Real Analysis

1. Least upper bound, Greatest lower bound and Limit of a sequence.
2. Limsup, liminf of a sequence.
3. Finding limit of Cauchy sequences and Alternating series.
4. Convergence, Divergence of series.
5. Conditional Convergence and Absolute convergence of series.
6. Finding Darboux's sum of Function.
7. Finding Riemann Integral of a function.
8. Improper integral of First and Second Kind.
9. Improper integral of Third Kind.
10. Comparison tests.

B. Modern Algebra

1. Groups and Abelian Groups
2. Generators of Cyclic groups
3. Finding order of Permutation and composition of two or more Permutation.
4. Center of Group, Normaliser of Subgroup
5. Cosets of group.
6. Finding zero divisors, Characteristics, Idempotent and Nilpotent element of Ring.
7. Finding Range and Kernels of Homomorphism in Groups and rings.
8. Forming Quotient groups, Quotient rings.
9. Ideals of Rings.
10. Finding Maximal and Prime ideals of rings

C. Partial Differential Equation

1. Eliminating arbitrary constants and function.
2. Cauchy's problem for first order equation.
3. Lagrange's method for solving PDE.
4. Charpit's Method.
5. Standard form I (only p and q present) and Standard form II (Clairaut's Equation).
6. Standard form III (only p, q and z present) and Standard form IV (f (x, p) = g (y, q)).
7. Solving Homogeneous linear PDE with constant coefficients when f(x,y) is of the form e^{ax+by}.
8. Solving Homogeneous linear PDE with constant coefficients when f(x,y) is of the form sin(ax+by) or cos(ax+by).
9. Solving Homogeneous linear PDE with constant coefficients when f(x,y) is of the form $x^m y^n$.
10. Reducible and Irreducible linear PDE with constant coefficients.

D. Relativity

1. Galilean Transformations and Newtonian Relativity.
2. Conservation laws in Newtonian Mechanics.
3. Maxwell's electromagnetic theory.
4. The Michelson – Morley experiment.
5. Lorentz Transformations and its consequences.
6. Group properties of Lorentz Transformations.
7. The mass of a moving particle m=m_0/√(1-u^2/C^2) Relativistic expression for Force.
8. Mass energy equivalence E = mc^2. Transformation equations for mass.
9. Transformation equations for momentum and energy.
10. Minkowski Space (Four dimensional Continuum). Time-like, Space- like, Light – like (null) intervals.

OR

D. Numerical Methods

1. Newton's forward interpolation and Newton's backward interpolation
2. Lagrange's interpolation
3. Newton's Divided difference interpolation
4. Newton's forward differentiation for Tabular Value
5. Newton's backward differentiation for Tabular Value
6. Trapezoidal rule
7. Simpson's 1/3rd rule
8. Simpson's 3/8th rule
9. Euler's Method and Euler's Modified Method
10. Second order Runge-Kutta method and Fourth order Runge-Kutta method

B. Sc. Part – III Semester -V Mathematics
MIN-PR-V : MIN03MAT59 : MIN Mathematics Lab-5
Practical 4 Lectures of 60 minutes per week per batch
Marks-25 (Credits: 02)

1. Newton's forward interpolation and Newton's backward interpolation
2. Lagrange's interpolation
3. Newton's Divided difference interpolation
4. Newton's forward differentiation for Tabular Value
5. Newton's backward differentiation for Tabular Value
6. Trapezoidal rule
7. Simpson's 1/3rd rule
8. Simpson's 3/8th rule
9. Euler's Method and Euler's Modified Method
10. Second order Runge-Kutta method and Fourth order Runge-Kutta method

B. Sc. Part – III Semester -VI Mathematics
DSC XII : DSC03MAT61 : Metric Space
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able 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	Title of unit & Contents	Hours Allotted
1	**LIMIT AND METRIC SPACE:** Limit of a function on the real line, Metric spaces, Limits in metric spaces.	09
2	**CONTINUOUS FUNCTION ON METRIC SPACE:** Functions continuous at a point on the real line, Reformulation, Functions continuous on a metric space, Open sets, Closed sets, Discontinuous functions on R.	09
3	**CONNECTEDNESS AND COMPLETENESS:** More about open sets, connected sets, bounded sets and totally bounded sets, Complete metric spaces.	06
4	**COMPACTNESS:** Compact metric spaces, Continuous functions on compact metric spaces, Continuity of the inverse function, Uniform continuity.	06

Recommended Books:
1. Richard R. Goldberg, Method of Real Analysis, Oxford and IBH publishing CO. PVT.LTD.

Reference Book:
1. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House.

B. Sc. Part – III Semester -VI Mathematics
DSCXII: DSC03MAT62: Linear Algebra
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:

On completion of the course, the students will be able to:

CO1: understand the concepts of vector spaces, subspaces, bases, dimension and their properties.

CO2: learn properties of inner product spaces and determine orthogonality in inner product space.

CO3: learn basic concepts of linear transformation, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.

CO4: familiarize characteristic roots and characteristic vectors.

UNIT	Title of unit & Contents	HOURS ALLOTED
1	**VECTOR SPACES:** Vector Spaces, Subspaces, Sum of Subspaces, Quotient Spaces, Homomorphisms or Linear Transformations, Linear Span, Linear Dependence and Independence	08
2	**INNER PRODUCT SPACES:** Norm of a Vector, Inner product spaces, Orthogonality, Orthonormal Set	07
3	**LINEAR TRANSFORMATIONS:** Algebra of Linear Transformations, Invertible Linear Transformations, Matrix of a Linear Transformation, Dual Spaces, Transpose of a Linear Transformation.	08
4	**EIGEN VALUES AND EIGEN VECTORS:** Eigen Values and Eigen Vectors, Characteristic Polynomials, Characteristic Polynomial of a Linear Operator	07

Recommended Book:

1. V. K. Khanna and S. K. Bhambri, A course in abstract algebra, 5th edition, Vikas publishing house Pvt. Ltd.

Reference book:

1. Vivek Sahai & Vikas Bist, Linear Algebra (Second Edition) Narosa Publishing House.
2. Seymour Lipschitz & Mark Lipson, Linear Algebra (Third Edition) Schaum's Outlines TATA McGraw-Hill edition.

B. Sc. Part – III Semester -VI Mathematics
DSCXIV: DSC03MAT63: Complex Analysis
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: understand the significance of differentiability of complex functions leading to the understanding of Cauchy- Riemann equations.
CO2: understand the exponential function, Logarithmic function, Trigonometric function.
CO3: apply Cauchy integral formula to evaluate integrals.
CO4: represent functions as Taylor, power and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

UNIT	Title of unit & Contents	Hours Allotted
1	**ANALYTIC FUNCTIONS:-** Functions of a Complex Variables, Limits. Theorems on limits (Without Proof), Limits involving the point at infinity. Continuity. Derivatives, Differentiation formulas (Without Proof), Cauchy- Riemann Equations, necessary and Sufficient Conditions for differentiability (Only Statement and Examples), Polar coordinates, Analytic functions, Harmonic functions.	08
2	**ELEMENTARY FUNCTIONS:-** The Exponential functions, The Logarithmic function, Branches and derivatives of logarithms, Some identities involving logarithms, Complex exponents, Trigonometric functions	07
3	**INTEGRALS:-** Derivatives of functions, Definite integrals of functions, Contours, Contour integral, Examples, Upper bounds for Moduli of contour integrals, Anti-derivatives (Only Examples), Cauchy-Goursat Theorem(Statement Only). Simply and multiply Connected domains. Cauchy integral formula, Derivatives of analytic functions. Liouville's Theorem and Fundamental Theorem of Algebra (Without Proof).	08
4	**SERIES:-** Convergence of sequences and series (Theorems without proof), Taylor's series (without proof), Laurent series (without proof), examples only, Isolated singular points, Residues, Zeros of analytic functions, zeros and poles.	07

Recommended Books:
1.James Ward Brown, Ruel V. Churchill, Complex Variables and Application, Mc Graw Hill Education – Eighth Edition.

Reference Books:
1.S. Ponnusamy, Foundation of complex analysis, Narosa Publishing House, - second Edition.
2. H.S KASANA, Complex Variables Theory & Applications PHI Learning Private Ltd. New Delhi.

B. Sc. Part – III Semester -VI Mathematics
MIN-X: MIN03MAT61: Basics of Operation Research
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: analyse and solve linear programming models of real-life situations.
CO2: formulate and apply suitable methods to solve problems.
CO3: identify and select procedures for various sequencing, assignment, transportation problems.
CO4: model competitive real-world phenomena using concepts from game theory and analyse pure and mixed strategy games.

UNIT	Title of unit & Contents	Hours Allotted
1	**LINEAR PROGRAMMING PROBLEM:** Revision of L.P.P., canonical form, standard form of L.P.P. Solution of L.P.P by Simplex method and examples, Solution of L.P.P by Big – M method and examples.	07
2	**TRANSPORTATION PROBLEM:** Basics of Transportation problem, Basic Definitions, Initial Solution: North – West corner method and examples, Matrix minima method and examples, Vogel's approximation method and examples. MODI method and examples, Unbalanced transportation problem and examples.	08
3	**ASSIGNMENT PROBLEM:** Introduction to Assignment problem, Hungarian method and examples, Unbalanced Assignment problem and examples, Assignment problems with restrictions and examples.	08
4	**THEORY OF GAMES:** Basics definitions, Saddle point and examples, Algebraic method for $\mathbf{2 \times 2}$ size game and examples, Arithmetic method for $\mathbf{2 \times 2}$ size game and examples, Principal of dominance, Dominance method and examples, Sub-game method for $\mathbf{2 \times n}$ & $\mathbf{m \times 2}$ size game and examples, Graphical method for $\mathbf{2 \times n}$ & $\mathbf{m \times 2}$ size game and examples.	07

Recommended Books:
1. S. D. Sharma: Operations Research, KedarNath RamNath Meerut, Delhi Reprint 2015.

Reference Books:
1. Kanti Swarup, P. K. Gupta, Man Mohan, Operations Research, Sultan Chand and Sons.

B. Sc. Part – III Semester -VI Mathematics
DSE-II DSE03MAT 61: Tensors
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: understand tensor algebra and calculus.
CO2: recognizing role of tensor in mathematical context.
CO3: apply tensor concept to solve real life problems.
CO4: understanding the role of tensor in formulating general relativity.

UNIT	Title of unit & Contents	Hours Allotted
1	**Tensors** Introduction, Space Vn, Einstein summation convention, Dummy suffix, Free suffix (Real suffix), Definition: Kronecker delta, Transformation of co-ordinates, Scalar (Invariant), Vector, Contravariant vector, Covariant vector, Rank (order) of tensor, Tensors of higher order: (a) Contravariant tensor of rank r, (b) Covariant tensor of order r, (c) Mixed tensor of order (r +s) Number of components of a tensor, Symmetric tensor, Skew – symmetric tensor, Number of distinct components of symmetric tensor and skew - symmetric tensor and Results	07
2	**TENSOR ALGEBRA** Addition of tensors, Theorem: The sum (or difference) of two tensors is a tensor of the same rank and similar character, Contraction, Property: Contraction reduces the rank of a tensor by two, Product (Multiplication) of tensors, Outer multiplication, Inner multiplication, The outer product (open product) of two tensors is a Tensor, Quotient law of tensors, Relative Tensor, Riemannian Metric, Fundamental Tensor, Associate Tensors, Raising and Lowering of suffixes	08
3	**TENSOR CALCULUS** Christoffel Symbols of 1st kind and 2nd kind, Transformation law for Christoffel symbols, Theorem: To Prove that i) $\Gamma_{ij,k}+\Gamma_{jk,i}=\frac{\partial g_{ik}}{\partial x^j}$ ii)$\Gamma^i_{ij} = \frac{\partial}{\partial x^j} log\sqrt{(-g)}$ iii)$\Gamma^i_{ij} = \frac{\partial}{\partial x^j} log\sqrt{g}$ iv)$\frac{\partial g^{ij}}{\partial x^k} = g^{ij}\Gamma^j_{ik} - g^{ij}\Gamma^j_{ik}$ Covarant derivative of a covariant vector and cotravariant vector, Covariant derivative of a covariant vector is a tensor of rank 2, Covarant derivative of a cotravariant vector is a tensor, Covariant differential of tensors, Covariant differentiations of tensor is a tensor,	07
4	**RELATIVITY AND ELECTROMAGNETISM** Introduction, Maxwell's equations of electromagnetic theory in vaccum, Propagation of electric and magnetic field strengths, Scalar and Vector potential, Four potential, Transformations of the charge density and current density, Current four vector, Gauge transformations, Four dimensional formulation of the theory, The electromagnetic field tensor, Maxwell's equations in tensor form	08

Recommended Books:
1. Karade T. M **,** Relativity and Tensor Calculus,. Einstein Foundation International, 1980.

Reference Books:
1**.** Tolman R. C., Relativity**,** Thermodynamics and Cosmology, At the Clarendon Press, 1934.

B. Sc. Part – III Semester -VI Mathematics
DSE-II: DSE03MAT62: Optimization Techniques
Theory: 30 hrs.
Marks-50 (Credits: 02)

Course Outcomes:
On completion of the course, the students will be able to:
CO1: analyse and solve linear programming models of real-life situations.
CO2: formulate and apply suitable methods to solve problems.
CO3: identify and select procedures for various sequencing, assignment, transportation problems.
CO4: model competitive real-world phenomena using concepts from game theory and analyse pure and mixed strategy games.

UNIT	Title of unit & Contents	Hours Allotted
1	**LINEAR PROGRAMMING PROBLEM:** Revision of L.P.P., canonical form, standard form of L.P.P. Solution of L.P.P by Simplex method and examples, Solution of L.P.P by Big – M method and examples	07
2	**TRANSPORTATION PROBLEM:** Basics of Transportation problem, Basic Definitions, Initial Solution: North – West corner method and examples, Matrix minima method and examples, Vogel's approximation method and examples. MODI method and examples, Unbalanced transportation problem and examples,	08
3	**ASSIGNMENT PROBLEM:** Introduction to Assignment problem, Hungarian method and examples, Unbalanced Assignment problem and examples, Assignment problems with restrictions and examples.	08
4	**THEORY OF GAMES:** Basics definitions, Saddle point and examples, Algebraic method for $\mathbf{2 \times 2}$ size game and examples, Arithmetic method for $\mathbf{2 \times 2}$ size game and examples, Principal of dominance, Dominance method and examples, Sub-game method for $\mathbf{2 \times n}$ & $\mathbf{m \times 2}$ size game and examples, Graphical method for $\mathbf{2 \times n}$ & $\mathbf{m \times 2}$ size game and examples	07

Recommended Books:
1. S. D. Sharma: Operations Research, KedarNath RamNath Meerut, Delhi Reprint 2015.

Reference Books:
1. Kanti Swarup, P.K.Gupta, Man Mohan, Operations Research, Sultan Chand and Sons

B. Sc. Part – III Semester -VI Mathematics
VSC-PR-IV: VSC03MAT69: Numerical methods Using Scilab
Practical 04 Lectures of 60 minutes per week per batch
Marks-25 (Credits: 02)

Practicals:

1. Basic Elements of Scilab as a Programming Language: Scilab Editor, Scilab Keywords, Predefined Variables, Input and Output Statements, Assignment statements, Simple Programs based on elementary operators
2. Conditional structure: if-else, if-elseif-else, select-case, Simple Programs based on conditional structure.
3. Looping structure: for loop, while loop, break and continue statement, Simple Programs based on Looping structure.
4. Functions: Defining custom functions and Programs based on it.
5. Recursive Functions: Defining Recursive functions and Programs based on it.
6. Plotting graph: Creating two dimensional graphs of simple functions.
7. Euler's method and Euler's Modified method
8. Runge-Kutta 2nd Order and 4th Order
9. Trapezoidal, Simpson's 1/3rd And 3/8th method
10. Weddles method

Reference Book :

1. Advanced Programming in SciLab: Chetana Jain, Alpha Science International Ltd (2020).
2. Engineering and Scientific Computing with Scilab 1999th Edition by Claude Gomez (Editor), C. Bunks (Contributor), J.-P. Chancelier (Contributor), F. Delebecque (Contributor), M. Goursat (Contributor), R. Nikoukhah (Contributor), S. Steer (Contributor)

B. Sc. Part – III Semester -VI Mathematics
OJT: OJT03MAT61: On Job Training
Practical 04 Lectures of 60 minutes per week per batch
Marks-50 (Credits: 02)

Guidelines

To get detailed guidelines follow the link :
https://www.vivekanandcollege.ac.in/uploads/nep/Policies/Policy-OJT-Internship%20%20VCK.pdf

B.SC. Part III Semester-VI Mathematics
DSC- PR-VI: DSC03MAT61: DSC Mathematics Lab -6
Practical 12 Lectures of 60 minutes per week per batch
Credits: 06
Marks-75 [17(A)+17(B)+17(C)+17(D)+05(J)+02(O)]

Practicals:

A. Metric Space

1. Metric space **(02)**
2. Open ball and Open set
3. Limit point of a set in usual metric space and Closure of a set
4. Interior and Exterior of a Set
5. Closed ball and Closed set
6. Complete space
7. Connected set

B. Linear Algebra

1. Vector spaces
2. Subspaces
3. Homomorphism and Isomorphism
4. Linear dependence and independence
5. Basis
6. Inner product space
7. Gram-Schmidt orthogonalization process
8. Algebra of linear Transformations.
9. Matrix of a Linear Transformation.
10. Eigen Values and Eigen Vector

C. Complex Analysis

1. Necessary and Sufficient Condition for differentiability
2. Cauchy-Rieman Equation
3. Exponential, Logarithmic function and Branches and derivatives of logarithms.
4. Complex Exponents and Trigonometric function
5. Complex integration
6. Cauchy integral formula
7. Derivative of Analytical function and Liouville's Theorem
8. Taylor's and Laurent's Series
9. Singularity
10. Residues Zeros of analytic functions.

D. Tensor

1. Transformation of co- ordinates
2. Symmetric tensor
3. Addition of tensors, Contraction of tensor
4. Product and Quotient of tensor
5. Reciprocal Symmetric and Relative Tensor
6. Tensor calculus
7. Covariant differential of tensors
8. Maxwell's equations
9. Transformations of the charge density and current density,
10. Gauge transformations and Four-dimensional formulation

OR

D. Optimization Technique

1. Graphical method for linear programming problems.
2. Solution of LPP using Simplex method and Solution of LPP using Big – M method
3. North – West corner method and Matrix minima method
4. Vogel's approximation method
5. MODI method
6. Unbalanced transportation problem
7. Hungarian method and Unbalanced Assignment problem
8. Algebraic method for 2×2 size game and Arithmetic method for 2×2 size game
9. Sub-game method for 2×n & m×2 size game
10. Graphical method for 2×n & m×2 size game

B. Sc. Part – III Semester -VI Mathematics
MIN-PR-VI : MIN03MAT69 : MIN Mathematics Lab-6
Practical 4 Lectures of 60 minutes per week per batch
Marks-25 (Credits: 02)

1. Graphical method for linear programming problems.
2. Solution of LPP using Simplex method and Solution of LPP using Big – M method
3. North – West corner method and Matrix minima method
4. Vogel's approximation method
5. MODI method
6. Unbalanced transportation problem
7. Hungarian method and Unbalanced Assignment problem
8. Algebraic method for 2×2 size game and Arithmetic method for 2×2 size game
9. Sub-game method for 2×n & m×2 size game
10. Graphical method for 2×n & m×2 size game