S.S. JAIN SUBODH P.G. COLLEGE

RAM BAGH CIRCLE, JAIPUR-302004

DETAILED COURSE STRUCTURE & SCHEME OF EXAMINATION

AS PER

UGC CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMMES UNDER NEP 2020

FOR

B.Sc. (MATHEMATICS)

(2023-2024 & ONWARDS)

Medium of Instruction: Hindi/ English

B.Sc. Mathematics

The Bachelor's Degree in B.Sc. Mathematics is awarded to the students on the basis of knowledge, understanding, skills, attitudes, values and academic achievements sought to be acquired by learners at the end of this program. Hence, the learning outcomes of mathematics for this course are aimed at facilitating the learners to acquire these attributes, keeping in view of their preferences and aspirations for knowledge of mathematics. Mathematics is the study of quantity, structure, space and change. It has very broad scope in science, engineering and social sciences. The key areas of study in mathematics bare Calculus, Algebra, Geometry, Analysis, Differential Equations and Mechanics.

Programme Specific Outcome

- Think in a critical manner.
- Familiarize the students with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences.
- Acquire good knowledge and understanding to solve specific theoretical and applied problems in advanced areas of mathematics and statistics.
- Provide students/learners sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics.
- Encourage the students to develop a range of generic skills helpful in employment, internships and social activities.

Program Outcome

PO-1: Ability to acquire in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of mathematics. This also leads to study of related areas like computer science and physical science. Thus, this Program helps learners in building a solid foundation for higher studies in mathematics.

PO-2: The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modeling and solving real life problems.

PO-3: To recognize patterns and to distinguish between essential and irrelevant aspects of problems.

PO-4: Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.

PO-5: Ability to share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

PO-6: Ability to communicate mathematics effectively by written, computational and graphic means.

PO-7: Create mathematical ideas from basic axioms.

PO-8: Ability to apply multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

PO-9: Able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians

PO-10: This Program will also help students to enhance their employability for jobs in banking, insurance and investment sectors, data analyst and in various other public and private enterprises.

Scheme for Choice Based Credit System in B.Sc. Mathematics

NHEQF Level	Course Code	Course Title	Course Category	Credit	Contact Hours per week			ESE Duration (Hrs.)	
					L	T	P	T	P
Semester-I									
5	SSMA101	Differential Calculus	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA102	Analytic Geometry	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA103	Discrete Mathematics	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA151	Mathematics Practical-I	DSC	**6**	**-**	**-**	**12**	**-**	**4**
Semester-II									
5	SSMA201	Integral Calculus	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA202	Abstract Algebra	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA203	Graph Theory	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA251	Mathematics Practical-II	DSC	**6**	**-**	**-**	**12**	**-**	**4**
Semester-III									
6	SSMA301	Numerical Analysis	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA302	Real Analysis-I	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA303	Differential Equations-I	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA351	Mathematics Practical-III	DSC	**6**	**-**	**-**	**12**	**-**	**4**
Semester-IV									
6	SSMA401	Complex Analysis	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA402	Real Analysis-II	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA403	Differential Equations- II	DSC	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA451	Mathematics Practical-IV	DSC	**6**	**-**	**-**	**12**	**-**	**4**
Semester-V									
7	SSMA501A/ SSMA501B	DSE A	DSE	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA502A/ SSMA502B	DSE B	DSE	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA503A/ SSMA503B	DSE C	DSE	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA551	Mathematics Practical-V	DSC	**6**	**-**	**-**	**12**	**-**	**4**
Semester-VI									
7	SSMA601A/ SSMA601B	DSE D	DSE	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA602A/ SSMA602B	DSE E	DSE	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA603A/ SSMA603B	DSE F	DSE	**3**	**3**	**-**	**-**	**3**	**-**
	SSMA651	Mathematics Practical-VI/ Project work	DSC	**6**	**-**	**-**	**12**	**-**	**4**

Discipline Subject Elective (DSE) for Semester V

DSE A (Choose any one)	DSE B (Choose any one)	DSE C (Choose any one)
1. SSMA501A: Advanced Abstract Algebra	1. SSMA502A: Advanced Complex Analysis	1. SSMA503A: Dynamics
2. SSMA501B: Operation Research-I	2. SSMA502B: Matrices	2. SSMA503B: Statistics

Discipline Subject Elective (DSE) for Semester VI

DSE D (Choose any one)	DSE E (Choose any one)	DSE F (Choose any one)
1. SSMA601A: Linear Algebra	1. SSMA602A: Number Theory	1. SSMA603A: Mechanics
2. SSMA601B: Operation Research-II	2. SSMA602B: Theory of Equations	2. SSMA603B: Vector Calculus

Note: If Candidate select the DSE paper SSMA501A in the Semester-V then candidate will select the corresponding DSE paper SSMA601A in the Semester-VI. Same selection procedure for other elective papers also.

Examination Scheme for Theory Paper

Part A- Question1 is compulsory comprises eight very short questions (Two from each Unit). Candidate has to attempt any seven questions. Each question carries 2 marks.
7×2 mark each = 14 Marks

Part B Comprises 4 questions (one question from each unit with internal choice) and all questions are compulsory. Each Question Carries 10 Marks.
4×10 mark each = 40 Marks

Total of End semester exam (duration of exam 3 hours) = 54 Marks
Internal Assessment = 21 Marks

Examination Scheme for Practical Paper

Max. Practical Marks = 150 Marks
Internal Practical Examination = 60 Marks
Marks External Practical Exam. (Duration: 4 hrs.) = 90 Marks
Distribution of Marks:
Four Practical one from each group 15 Marks each = 60 Marks
Practical Record: 15 Marks
Viva-voice: 15 Marks
Note: 1. Each Candidate has to prepare his/ her practical record.
2. Each Candidate has to pass in Practical and Theory examination separately.

Evaluation Scheme of Project

Total Marks 150
Internal Marks: 60
Viva-Voice: 30 Marks
Presentation: 30 Marks
Project: 30 Marks

B.SC. (MATHS) I SEMESTER

Paper I: Differential Calculus
Course Type: DSC

Prerequisite: Student must know about differentiation and its applications.
Course Objective: The primary objective of this course is to introduce the basic tools of calculus, the idea of derivative, tangent line to the graph of a function.

Unit I: Infinite Series: Convergence of series of non-negative terms, their various tests (Comparison; D'Alembert's ratio, Cauchy's n^{th} root, Raabe's, Gauss, Logarithmic, DeMorgan and Bertrand's, Cauchy's condensation (proof of tests not required)) for convergence. Alternating series, Leibnitz's test, Series of arbitrary terms, absolute and conditional convergence.
Unit II: Derivative of the length of an arc, Pedal Equations, Curvature-various formulae, Centre of curvature, Chord of curvature and related problems.
Unit III: Partial differentiation, Euler's Theorem for Homogeneous functions, Chain Rule of Partial Differentiation, Total differential Coefficient, Differentiation of implicit functions.
Unit IV: Envelops, Maxima and Minima of function of two variables, Lagrange's Method of undetermined multipliers.

Reference Books:

1. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
2. H. Anton, I. Bivens and S. Davis, Calculus (7th Edition), John Wiley and sons (Asia), Pt Ltd., Singapore, 2002.
3. International Publication, New Delhi
4. Gupta &Kapoor, 2000 (First Edition), "Text book of differential calculus", S. Chand Publication, New Delhi.
5. A.R. Vasishtha, S.K. Sharma, A. K. Vasishtha, 1989 (First Edition)"Differential Calculus", Krishna Prakashan Media, Meerut.

Course Outcome: On successful completion of this course, Students is able to understand the idea of derivative, tangent line to the graph of a function, how a derivative can be used to describe the rate of change of one quantity with respect to another, and how to relate the geometric ideas to the analytic ideas.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/ , https://www.khanacademy.org/ , https://alison.com/tag/maths

Paper II: Analytic Geometry
Course Type: DSC

Prerequisite: Student must know about the basic knowledge of geometry.
Course Objective: The aim of the course is to develop connection between algebra and geometry through graphs of lines and curves.to understand the concept of conic, sphere, cone and central conicoid.

Unit I: Polar equation of conic: General equation of Conic (Focus being the pole), Director Circle, Auxiliary circle, Chord, Tangent, Chord of Contact, Normal, Pole and Polar, perpendicular lines and Asymptotes.
Unit II: Sphere: Equation of sphere, intersection of two spheres, diameter form, tangent line and tangent plane, condition of tangency, pole and polar plane, condition of orthogonality.
Unit III: Cone: Equation of Cone (whose vertex and guiding curve are given), Enveloping cone, right circular cone.
Cylinder: Equation of cylinder, enveloping cylinder, Right circular cylinder.
Unit IV: Central Conicoid: Introduction, Intersection of a line and a Central Conicoid, Tangent line and tangent planes, condition of tangency for a plane. Generating lines of hyperboloid of one sheet and its properties.

Course Outcome: On successful completion of this course, Students will be able to understand the basic applications of coordinate geometry. They will develop ability to pursue advanced studies and research in pure and applied mathematical science.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) Pvt. Ltd., 2002.
3. S.L. Loney, The Elements of Coordinate Geometry, McMillan and Company, London.
4. R.J.T. Bill, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan India Ltd., 1994.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

Paper III: Discrete Mathematics
Course Type: DSC

Prerequisite: student must know about Set, Relation and Function.
Course Objective: This course aims at introducing the concepts of lattices, Boolean algebra and recurrence relation. The course discusses some important applications of Boolean algebra in real life situations.

Unit I: Sets: Principle of inclusion and exclusion, Russell Paradox and Mathematical Induction. Propositional calculus, Basic logical Proposition, truth table, Tautologies and contradiction.
Unit II: Relations and Functions: Binary Relations, Equivalence Relations and Partitions. Partial and total Order Relations, Lattices and algebraic structure. Chains and Anti-chains. Pigeon Hole Principle.
Unit III: Boolean algebras: Boolean functions and expressions (Using Identity / Truth table), conjunctive and disjunctive normal form, Duality, Boolean Lattices.
Unit IV: Discrete numeric Function and Generating Function, Recurrence Relations and recursive algorithm-Linear recurrence relations with constant coefficients. Homogeneous solutions, particular solution, Total solution, Solution by the method of generating functions.

Course Outcome: After completion of the course students are expected to be able to:
1. Analyze logical propositions via truth tables.
2. Prove mathematical theorems using mathematical induction.
3. Understand sets and perform operations and algebra on sets.
4. Determine properties of relations, identify equivalence and partial order relations, sketch relations.
5. Identify functions and determine their properties.

Reference Books:

1. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory 2nd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2003.
2. Rudolf Lidl and Günter Pilz, Discrete Mathematics: Elementary and Beyond, 2003.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths

Mathematics Practical-I
Course Type: DSC

The paper will contain four practical. The candidates are required to attempt all practical.

Course Objective: The main objective of this course is to gain proficiency in the field of optimization theory. The objectives of this course to understand the solution of linear programming problems and engineering problems related to Assignment and Transportation problems with applications of many real-world problems

Unit I: Linear programming problem formulation. Graphical solution of linear programming problems. Basic solution.
Unit II: Simplex method for solution of a L.P.P (Numerical Problems)
Unit III: Duality (Numerical Problems)
Unit IV: Modeling of Industry and engineering problems into Assignment and Transportation problems and their solution (Numerical Problems)

Course Outcome: On successful completion of this course students are able to understand the linear optimization theory and its applications. Student can identify the appropriate methods for the efficient computation of optimal solutions of a problem and a set of linear constraints.

Reference books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 8th Ed., Tata McGraw Hill, Singapore, 2004.
3. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.

B.SC. (MATHS) II SEMESTER

Paper I: Integral Calculus
Course Type: DSC

Prerequisite: student must know about integration and its properties.
Course Objective: The primary objective of this course is to gain proficiency in Integral Calculus. The objectives of this course are to consider applications of derivatives for sketching of curves, concept of Double and Triple integral, application of definite integrals for calculating volumes of solids of revolution, length of plane curves, Areas which are helpful in understanding their applications in plenary motion, design of telescope and to many real-world problems.

Unit I: Asymptotes, Multiple points, Curve tracing of standard curves (Cartesian and polar curves).

Unit II: Introduction of Beta and Gamma functions. Double integrals in Cartesian and polar coordinates. Change of order of integration (Cartesian and polar coordinates).

Unit III: Triple integrals, Dirichlet's Integration, Rectification.

Unit IV: Areas, Volumes and surfaces of solids of revolution.

Course Outcome: On successful completion of this course, Students will enable to sketch curves in a plane using its mathematical properties in the different coordinate systems of reference. Student will able to compute the length of curve, area bounded by the curves, area and volume of surface of solid of revolution.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen, Calculus (10th Ed.), John Wiley & Sons Singapore Pvt. Ltd. Reprint (2016) by Wiley India Pvt. Ltd. Delhi.
2. Strauss, M. J., Bradley, G. L., & Smith, K. J. (2007). Calculus (3rd Ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Sixth impression 2011.
3. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

Online resources: https://www.coursera.org/ , https://www.khanacademy.org/ , https://alison.com/tag/maths

Paper II: Abstract Algebra
Course Type: DSC

Prerequisite: The student must know the basic knowledge of set, relation and functions.
Course Objective: The main aim of the course is to introduce you to basic concepts from abstract algebra, especially the notion of a group. The Abstract Algebra module focuses on the power of abstraction by developing mathematical theories from axioms in several contexts – Group Theory, Rings and Fields.

UNIT I: Definition and simple properties of Groups and subgroup, cyclic group, Permutation group. Cosets, Lagrange's theorem on the order of subgroups of a finite order group.
UNIT II: Normal subgroups and Quotient groups. Morphism of groups, Fundamental theorems of Isomorphism, Cayley's theorem.
UNIT III: Definition and simple properties of Rings, Integral domain and field.
UNIT IV: Characteristics of a Ring and Field, Sub rings, Subfield, Embedding of a ring, Morphism of rings.

Course Outcome: The students who succeeded in this course; will able construct and compare algebraic structures and substructures and analyze a given structure in detail. They also understand a new structure based on given structures.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
6. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
7. D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

Paper III: Graph Theory
Course Type: DSC

Prerequisite: The student must know the basic knowledge of set, relation and function.
Course Objective: The course aims at introducing the concepts of types of graphs, Paths and circuits. It also includes introduction to Digraph and Binary Relations, some operations of graphs. Then some important concept of Trees explained. The other part of the course deals with planar graphs and matrix representation also.

Unit I: Graph Theory- simple graph, Multi graph, properties of graph, Degree of Vertex, Directed Graph, Undirected Graph, Digraph and binary relation, Regular graph, n-Regular graph, size of n-Regular graph, Sub Graphs, Complete Graph, Cycles, wheels, Bipartite graph, Matrix representation of Graph and Digraph.
Unit II: Union, Join, Product, and composition of graphs, Complementary graph, Isomorphic graph, Cut sets, bridge, edge connectivity, vertex connectivity, Connected and disconnected graphs, Seperable graph, walk, open and closed walk, length of walk, Trail, Path, Circuit, Euler path, Euler graph, Hamiltonian cycle and path, Hamilton Graph.
Unit III: Weighted graph, Shortest path problem, Planar & non-Planar Graph and its properties, region, degree of region, Euler's formula, Homeomorphic graph and Dual graphs.
Unit IV: Trees- Properties, Distance between two vertices, eccentricity of vertex, centre of a graph, Rooted Tree, Binary Tree, Height of a tree, Balanced rooted tree, Spanning Tree, Minimal Spanning Tree: Kruskal's Algorithm and Prim's Algorithm.

Course Outcome: The students will be able to
1. Understand the basics of graph theory and their various properties.
2. Model problems using graphs and to solve these problems algorithmically.
3. Apply graph theory concepts to solve real world applications like routing, TSP/traffic control, etc.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. Davey, B. A., & Priestley, H. A. (2002). Introduction to Lattices and Order (2nd Ed.). Cambridge University press, Cambridge.
2. Goodaire, Edgar G., & Parmenter, Michael M. (2011). Discrete Mathematics with Graph Theory (3rd ed.). Pearson Education (Singapore) Pvt. Ltd. Indian Reprint.
3. Lidl, Rudolf & Pilz, Gunter. (2004). Applied Abstract Algebra (2nd ed.), Undergraduate Texts in Mathematics. Springer (SIE). Indian Reprint.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

Mathematics Practical-II
Course Type: DSC

The paper will contain four practicals by the use of SCI Lab. The candidates are required to attempt all practical.

Course Objective: Student will learn about the application of SCI Lab.

Unit I: Plotting the graphs of the following function $ax,\ \sqrt{ax+b},\ |ax+b|,\ c \pm |ax+b|,\ x^{\pm n},\ x^{1/n}(n \in Z),\ e^{ax+b},\ log(ax+b), sin(ax+b), cos(ax+b), |sin(ax+b)|, |cos(ax+b)|$. Observe and discuss the effects of change in the real constant a, b and c on the graphs

Unit II: Graphs of hyperbolic functions and inverse trigonometric functions, Plotting and analyzing the graphs of polynomials and their derivatives.

Unit III: Complex numbers: Operations like addition, subtraction, multiplication, division, Modules and inbuilt functions conj, imag, imult, isreal, real.
Marix operations: Addition, Multiplication, Inverse. Transpose. Determinant, Rank and inbuilt functions eye, ones, zeros

Unit IV: Solving the system of linear equations, Solution of linear programming problems by using inbuilt functions of SCI Lab

Course Outcome: Student will able to plot the graphs of various functions and apply the SCI lab in the calculation for Complex numbers, Matrix and linear equations.

References: 1. SCI Lab Free Software to MATLAB) by Ramachandran Hema Nair Achuthsankar S.
2. Programming in SCI Lab, Ranjan Goyal, Mansi Dhingra.
3. SCI Lab by Praveen Garg, Jaipur Publishing House

B.SC. (MATHS) III SEMESTER

Paper I: Numerical Analysis
Course Type: DSC

Prerequisite: The student must know the basic knowledge of scientific calculator and numerical solutions.
Course Objectives: To provide the numerical methods of solving the non-linear equations, interpolation, differentiation, and integration. To improve the student's skills in numerical methods by using the numerical analysis and computer facilities.

Syllabus:
Unit I: Introduction of forward and backward differences, Interpolation with equal interval: Newton's Formula for Forward and Backward interpolation. Interpolation with unequal interval: Divided Differences, Newton's Divided difference interpolation formula, Lagrange's Interpolation Formula.
Unit II: Central Differences: Gauss's forward and backward Formula, Sterling Formula, Bessel's formula, Numerical Differentiation and Integration, Trapezoidal Rule, Simpson's 1/3 and 3/8 Rule.
Unit III: Numerical Solutions of algebraic and Transcendental Equations, Method of Iteration, Bisection Method, Secant method, Regula-Falsi Method, Newton-Raphson Method. Gauss Elimination and Iterative Method (Jacobi and Gauss-Seidal Method) for solving system of linear algebraic simultaneous equations.
Unit IV: Numerical Solutions of differential equations, Initial value and boundary value problem, Picard's method, Euler's Method, Modified Euler Method, Third and fourth order Runge-Kutta Methods.

Course Outcome: Students are able to
1. Understand the nature and operations of Numerical Analysis, demonstrate familiarity with theories and concepts used in Numerical Analysis
2. Identify the steps required to carry out a piece of research on a topic in Numerical Analysis,
3. Apply Numerical Methods to find the value of derivatives
4. To solve integrals and simultaneous algebraic equations.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.
Reference Books:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.
3. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.
4. Bansal& Ojha, 1989 (First Edition), "Numerical Analysis" JPH Publication, Jaipur.
5. S S Shastri, 2003 (First Edition), " Numerical Analysis", New Age Publication, New Delhi.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/,

https://alison.com/tag/maths.

Paper II: Real Analysis-I
Course Type: DSC

Prerequisite: The student must know the basic knowledge of real number system.
Course Objective: This course aims to provide students with the specialist knowledge necessary for basic concepts in Real Analysis. More precisely, it strives to enable students to learn basic concepts about functions of bounded variation and learn about Limit, Continuity and Differentiability.

UNIT I: Real numbers as a complete ordered field, limit point, Bolzano-Weierstrass Theorem, Closed and open sets, union and intersection of open and closed sets, concept of compactness, Heine-Borel Theorem, Connected sets.
UNIT II: Real sequence- Limit and Convergence of a sequence, Monotonic sequences. Cauchy's Sequences, Subsequences, Cauchy's general Principle of convergence.
UNIT III: Notion of Limit, Continuity, Properties of continuous function on closed intervals. Uniform Continuity, Limit and Continuity on functions of two variables.
UNIT IV: Differentiability, Properties of derivable functions, Derivative of Composite function, derivative of the inverse function, Darboux's and Roll's Theorem, Directional Derivatives, The total derivative, expression of total derivative in terms of partial derivative.

Course Outcome: On successful completion of this course, Students
1. Describe fundamental properties of the real numbers that lead to the formal development of real analysis.
2. Comprehend regions arguments developing the theory underpinning real analysis
3. Demonstrate an understanding of limits and how that is used in sequences, series and differentiation.
4. Construct rigorous mathematical proofs of basic results in real analysis.
5. Appreciate how abstract ideas and regions methods in mathematical analysis can be applied to important practical problems.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.
2. K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2004.
3. Mattuck, Introduction to Analysis, Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006.

Online resources: https://www.coursera.org/ , https://www.khanacademy.org/ , https://alison.com/tag/maths

Paper III: Differential Equations-I
Course Type: DSC

Prerequisite: The student must know the basic knowledge of differential equation.
Course Objective: To provide students with an introduction to the theory of ordinary differential equations through applications, methods of solution, and numerical approximations.

UNIT I: Degree and order of a differential equation, Equations of first order and first degree, Equation in which the variables are separable, Homogeneous equations and equation reducible to homogeneous form, Linear equations and Equation reducible to Linear form, Exact Differential Equations and equations which can be made exact.
UNIT II: First order but higher degree differential equations, solvable for x, y and p. Clairaut's form, and singular solutions with extraneous loci. Linear differential equation with constant coefficients, complementary functions, particular integral.
UNIT III: Homogeneous Linear differential Equation of Higher Order, Simultaneous differential Equation.
UNIT IV: Exact Linear Differential Equation upto nth order, existence and uniqueness theorem. Total Differential Equation.

Course Outcome: On successful completion of this course students will be able to:

1. understand that physical systems can be described by differential equations
2. understand the practical importance of solving differential equations
3. appreciate the importance of establishing the existence and uniqueness of solutions
4. recognise an appropriate solution method for a given problem
5. analytically solve a wide range of ordinary differential equations (ODEs)

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach Using Maple, Taylor and Francis, London and New York, 2002.
2. C. H. Edwards and D. E. Penny, Differential Equations and Boundary Value Problems: Computing and Modeling, Pearson Education, India, 2005.
3. S. L. Ross, Differential Equations, John Wiley and Sons, India, 2004.

Online resources: https://www.coursera.org/ , https://www.khanacademy.org/ , https://alison.com/tag/maths

Mathematics Practical-III (Basic C-Programming)
Course Type: DSC

The paper will contain four practicals by the use of C-Programming. The candidates are required to attempt all practical.

Course Objective: Student will learn about the basic concept of C-programming.

Programming languages and problem solving on computers, Algorithm, Flow chart, Programming in C- Constants, Variables, Arithmetic and logical expressions, Input-Output, Conditional statements, Implementing loops in Programs, Defining and manipulation arrays and functions.

Unit I: Printing n terms of Fibonacci sequence, finding $n!, \sum n, \sum n^2$ etc.
Unit II: Defining a function and finding sum of n terms of a series/sequence whose general term is given $e.g. a_n = \frac{n^2+3}{n+1}$, Printing Pascal's triangle, finding GCD and LCM of two numbers by Euclid's algorithm.
Unit III: Checking prime/composite number, finding number of primes less than $n, n \in Z$. finding mean, standard deviation and ${}^nP_r$, ${}^nC_r$ for different n and r.
Unit IV: Numerical integration using Trapezoidal, Simpson's 1/3, 3/8.

Course Outcome: Student familiar with basic C-programming in mathematics.
References: 1. Numerical Methods with Basic Concepts in C Programming, Rahul Banarjee
2. Numerical Analysis and Programming in C, Dr. G.D singh, Dr. Har Dutt Singh
3. Introduction to C Programming & Numerical Methods Lab, Sanjoy Mondal, Samiran Banerjee, Ayan De.

B.SC. (MATHS) IV SEMESTER

Paper I: Complex Analysis
Course Type: DSC

Prerequisite: The student must know the basic knowledge of complex variables and real analysis.
Course Objective: This course aims to introduce the basic ideas of analysis for complex functions in complex variables. Particular emphasis has been laid on Analytic Function, Conformal Mapping, Bilinear Transformation and Complex Integration.

UNIT I: Complex plane, Connected and Compact sets, Curves and Regions in complex plane. Jordan Curve Theorem (statement only), Extended complex plane, Stereographic projection, Complex valued function-Limits, Continuity and Differentiability.
UNIT II: Analytic functions, Cauchy-Riemann equations (Cartesian and polar form), Harmonic functions, Construction of an analytic function.
UNIT III: Conformal mapping. Bilinear transformation and its properties. Elementary mappings: $f(z) = \frac{1}{z}, z + \frac{1}{z}, z^2, sinz, cosz, logz.$
UNIT IV: Complex integration, Complex line integrals, Cauchy integral theorem, Indefinite integral, Fundamental theorem of integral calculus for complex functions. Cauchy integral formula, Analyticity of the derivative of an analytic function, Morera's theorem, Poisson integral formula.

Course Outcome: The student is able to

1. Know the central importance of complex variables in analysis.
2. Grasped a deeper understanding of differentiation and integration in this setting
3. Know the tools and results of complex analysis including Cauchy's Theorem, Cauchy's integral formula

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.
2. Joseph Bak and Donald J. Newman, Complex Analysis, 39 2nd Ed., Undergraduate Texts in Mathematics, Springer Verlag New York, Inc., NewYork, 1997.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

Paper II: Real Analysis-II
Course Type: DSC

Prerequisite: The student must study the Paper I (Real Analysis –I) of IIIrd Semester.
Course Objective: The course will develop a deeper and more rigorous understanding of defining terms and proving results about Riemann integration and Uniform convergence of real functions which have wide applications in real-world problems.

UNIT I: Riemann Integration – Partition of a set, Lower and Upper Darboux Sum, Lower and upper Riemann integral, Definition of Riemann Integration, Integrability of Continuous functions,
UNIT II: Integrability of Discontinuous and Monotonic functions, Integrability of the modulus of an integrable function, Mean value Theorem of integral Calculus, Integral function, Primitive, Fundamental theorem of Integral calculus.
UNIT III: Sequence and series of functions- Point wise and Uniform Convergence, Cauchy's Criterion, M_n Test, Weiertrass M- Test, Abel's Test, Drichlet's test for Uniform Convergence of sequence and series of functions .
UNIT IV: Uniform convergence and continuity of sequence and series of functions, Term by Term Differentiation and Integration.

Course Outcome

1. Knowledge and Understanding: Learn the theory of Riemann-Stieltjes integrals, to be aquainted with the ideas of the total variation and to be able to deal with functions of bounded variation.
2. Intellectual Skills: Develop a reasoned argument in handling problems about functions, especially those that are of bounded variation.
3. General and Transferable Skills: Develop the ability to reflect on problems that are quite significant in the field of real analysis.

Learner support Material: Swayam(https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, Jones & Bartlett, Second Edition, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner, and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.

Online resources: https://www.coursera.org/ , https://www.khanacademy.org/ , https://alison.com/tag/maths

Paper III: Differential Equations–II
Course Type: DSC

Prerequisite: The student must study the Paper-II (Differential Equations –I) of IIIrd Semester.
Course Objective: The main objectives of this course are to teach students to form and solve partial differential equations and use them in solving some physical problems.

UNIT I: Linear Differential Equation of second order, Linear Independence of solutions, Solution by transformation of the equations by changing the dependent variable/ independent variables, Factorization of Operators, Method of Variation of parameters.
UNIT II: Non-linear differential equation of particular forms, Partial Differential Equations of first order, Lagrange's Linear Equation, Charpit's Method.
UNIT III: Homogeneous and non-homogeneous Linear Partial Differential Equations with constant coefficients, Partial Differential Equations reducible to equations with constant coefficients.
UNIT IV: Partial Differential Equations of second order: Simple problem based on Monge's method, Separation of variable and canonical form.

Course Outcome: On successful completion of this course students will be able to:
1. understand that physical systems can be described by differential equations
2. understand the practical importance of solving differential equations
3. analytically solve a wide range of differential equations
4. solve classical linear partial differential equations (PDEs)

Reference Books:

1. Tyn Myint-U and Lokenath Debnath, Linear Partial Differential Equation for Scientists and Engineers, Springer, Indian reprint, 2006.
2. Ioannis P Stavroulakis and Stepan A Tersian, Partial Differential Equations: An Introduction with Mathematica and MAPLE, World Scientific, Second Edition, 2004.

Learner support Material: Swayam(https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/ , https://www.khanacademy.org/ , https://alison.com/tag/maths

Mathematics Practical-IV(Use of C- Programming in Numerical Analysis)
Course Type: DSC

The paper will contain four practical by the use of C-Programming. The candidates are required to attempt all practical.

Course Objective: This course is an introduction to a broad range of numerical methods for solving mathematical problems that arise in science and engineering.

UNIT I: C Programming for the solution of algebraic and Transcendental Equations by Bisection Method, Regula-Falsi Method, Method of Iteration, Newton-Raphson Method
UNIT II: C Programming for the solution of System of linear Equation Gauss Elimination Method, Gauss Jordan Method.
Unit III: C Programming for the Matrix operation: Addition, Subtraction, Multiplication, Rank of a Matrix, Inverse of Matrix
Unit IV: C Programming for the Numerical solution of Differential Equation by Modified Euler, Runge Kutta Method of third and fourth order.

Course Outcome: the student will able to apply well known numerical technique to solve science and engineering problems and evaluate the results.

References: 1. Numerical Methods with Basic Concepts in C Programming, Rahul Banarjee
2. Numerical Analysis and Programming in C, Dr. G.D singh, Dr. Har Dutt Singh
3. Introduction to C Programming & Numerical Methods Lab, Sanjoy Mondal, Samiran Banerjee, Ayan De.

B.SC. (MATHS) V SEMESTER

DSE A: Advanced Abstract Algebra
Course Type: DSE

Prerequisite: The student must study the Abstract Algebra of II Semester.
Course Objective: This course introduces the basic concepts of Ideals, Quotient ring and Vector Space.

UNIT I: Ideals and Quotient Ring, Maximal ideal and Prime ideal, Principal Ideal domain.

UNIT II: Field of quotients of an integral domain, Prime fields. Definitions, Examples and Simple properties of Vector spaces and Subspaces.
UNIT III: Linear combination, Linear dependence and Linear independence of vectors. Basis and Dimension, Generation of subspaces. Sum of subspaces. Direct sum and Complement of subspaces
UNIT IV: Quotient space and its dimension, Linear Transformation and simple properties, Kernel of Linear transformation.

Course Outcome: The students who succeeded in this course; will able to understand the concept of ideals, field of quotient, vector space, basis, dimension and quotient space.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
4. Joseph J. Rotman, An Introduction to the Theory of Groups, 4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, Topics in Algebra, Wiley Eastern Limited, India, 1975.
6. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
7. D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE A: Operations Research-I
Course Type: DSE

Prerequisite: The student knows the basics of Linear Programming.
Course Objective: It can provide a more detailed and insightful analysis in decision making to the students. This allows them to implement more comprehensive and thorough solutions to problems. It can also help them understand how to analyze similar problems in the future.
UNIT I: Basics of Operation Research, Introduction, Models, Scope, Classification, Limitations of OR.
UNIT II: Theory of Games - Introduction, Basic definitions, Minimax (Maximin) criterion and optimal strategy, Saddle point, Minimax-Maximin principle for mixed strategy games.
UNIT III: Fundamental theorem of game theory, Two-by-two games without saddle point, Arithmetic method for 2 X 2 games, graphical method for 2 X 2 games.
UNIT IV: Sequencing Models: Sequencing Problems, Processing n jobs through two machines. Processing n jobs through three machines. Processing two through m machines, processing n jobs through shortest cyclic Route models. Minimal path problem (shortest Acyclic Route Models).

Course Outcome: On completion of the course, the student will be able to:

1. Understand the scope and classification of operation research.
2. Optimize the allocation of resources to Demand points in the best possible way using various techniques and minimize the cost or time of completion of number of jobs by number of persons.
3. Model competitive real-world phenomena using concepts from game theory. Analyse pure and mixed strategy games

Reference Books:

1. Kanti Swaroop, P.K.Gupta and Man Mohan: Operation Research. Sultan Chand.
2. Operation Research – S.D.Sharma.
3. Operations Research - Models and methods by Chandrasekar Salimath, Bhupendar Parashar.
4. Operation Research – Taha.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE B: Advanced Complex Analysis
Course Type: DSE

Prerequisite: The student must study the Complex Analysis of IV Semester.
Course Objective: This course aims to provide knowledge of power series, singularities, various theorems and their applications.

UNIT I: Power series-Absolute convergence, Abel's theorem, Cauchy-Hadamard theorem. Circle and Radius of convergence, Analyticity of the sum function of a power series, Analytic continuation. Power series method of analytic continuation.
UNIT II: Liouville's theorem, Taylor's theorem. Laurent's theorem, Maximal modulus theorem and Applications of these theorems.
UNIT III: Singularities of an analytic function, Riemann's theorem, Casorati-Weierstrass theorem, Residue at a singularity, Cauchy's residue theorem.
UNIT IV: Branch point, Meromorphic and Entire functions, Argument Principle. Rouche's theorem, Fundamental theorem of Algebra, Evaluation of a real definite integral by contour integration.

Course Outcome: After successful completion of this paper, student will able to understand the manipulation skills in the use of Rouche's theorem, Cauchy-Hadamard theorem, radius of convergence, Argument Principle, the principle of Analytic Continuation and the concerned results.

Reference Books:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw – Hill International Edition, 2009.
2. Joseph Bak and Donald J. Newman, Complex analysis (2nd Edition), Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE B: Matrices
Course Type: DSE

Prerequisite: The student must know the basic knowledge of Matrix Algebra.
Course Objective: In this course student will learn about the matrix and applications to solve the matrix equation AX = b using row operations and matrix operations. They will also learn about the characteristic equation, eigenvalues and corresponding eigenvectors of a given matrix.

UNIT I: Matrices R, R^2, R^3 as vector spaces over R. Standard basis for each of them. Concept of Linear Independence and examples of different bases. Subspaces of R^2, R^3.
UNIT II: Translation, Dilation, Rotation, Reflection in a point, line and plane. Matrix form of basic geometric transformations. Interpretation of Eigen values and Eigen vectors for such transformations and Eigen spaces as invariant subspaces.
UNIT III: Types of matrices. Rank of a matrix. Invariance of rank under elementary transformations. Reduction to normal form, Solutions of linear homogeneous and non-homogeneous equations with number of equations and unknowns upto four.
UNIT IV: Characteristic Equation, Characteristics Roots, Cayley Hamilton Theorem, Matrices in diagonal form. Reduction to diagonal form upto matrices of order 3. Computation of matrix inverses using elementary row operations and cayley Hamilton theorem. Rank of matrix. Solutions of a system of linear equations using matrices.

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

1. Find the inverse of a square matrix.
2. Solve the matrix equation Ax = b using row operations and matrix operations.
3. Find the determinant of a product of square matrices, of the transpose of a square matrix, and of the inverse of an invertible matrix
4. Find the characteristic equation, eigenvalues and corresponding eigenvectors of a given matrix.
5. Determine if a given matrix is diagonalizable.

Books Recommended

1. A.I. Kostrikin, Introduction to Algebra, Springer Verlag, 1984.
2. S. H. Friedberg, A. L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
3. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill, 1989.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE C: Dynamics
Course Type: DSE

Prerequisite: The student must know the basic knowledge of dynamics.
Course Objective: This course helps the students to develop skills and knowledge of standard concepts in mechanics and to become aware of their applications. The course aims at understanding the various concepts of Kinematics, SHM, Projectile motion and Moment of Inertia.

UNIT I: Velocity and acceleration-along radial and transverse directions, along tangential and normal directions, Simple Harmonic Motion, Hooke's law, Motion along horizontal and vertical elastic strings.
UNIT II: Motion in resisting medium- Resistance varies as velocity and square of velocity. Projectile Motion, Time motion of Projectile and its trajectory, Projection pass through a given point.
UNIT III: Motion on a smooth curve in a vertical plane. Motion on the inside and outside of a smooth vertical circle and Cyclodical Motion.
UNIT IV: Moment of inertia-M. I. of rods, Circular rings, Circular disks, Solid and Hollow spheres, Rectangular lamina, Ellipse and Triangle. Product of Inertia, Theorems of Parallel and Perpendicular axes. Principal Axis and Momental Ellipsoid.

Course Outcome: After studying this course, you should be able to:

1. Understand and use basic terms for the description of the motion of particles, Velocity and acceleration and their components.
2. Understand S.H.M., Hooke's law.
3. Understand the concept of terminal speed, and use it in solving mechanics problems in one dimension
4. Find M.I. and P.I. of various objects

Reference Books:

1. A.S. Ramsay, Statics, CBS Publishers and Distributors (Indian Reprint), 1998.
2. A.P. Roberts, Statics and Dynamics with Background in Mathematics, Cambridge University Press, 2003.
3. P.N. Chatterjee, Dynamics, Rajhans Publication.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE C: Statistics
Course Type: DSE

Course Objective: The main purpose of study statistics is to collect, analyze, and interpretate data.

UNIT I: Correlation and Regression, properties, Rank correlation, Methods of least squares and curve fitting.

UNIT II: Probability- Introduction, definition, events, algebra of events, Bernoulli's trials, conditional probability, Addition and Multiplication theorem of probability, Baye's theorem.

UNIT III: Random variable, Types of random variable, Probability mass function, Probability density function and properties. Expectation, Mathematical expectation of sum and product of two random variates, Variance.
UNIT IV: Univariate Distributions: Bernoulli distribution, Binomial Distribution, Poission Distribution, and Normal Distribution, Mean, Variance, Moments and Cumulants and simple problems

Course Outcome: Upon successful completion of this course, students will be able to:

1. Organize, manage and present data.
2. Analyse statistical data graphically using frequency distributions and cumulative frequency distributions.
3. Analyse statistical data using measures of central tendency, dispersion and location.
4. Use the basic probability rules, including additive and multiplicative laws, using the terms, independent and mutually exclusive events.
5. Translate real-world problems into probability models.
6. Derive the probability density function of transformation of random variables.

Learner support Material: Swayam(https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. Gupta and Kapoor, Mathematical Statistics, S. Chand. 2019.
2. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.
3. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics with Applications (7th Edition), Pearson Education, Asia, 2006.
4. Sheldon Ross, Introduction to Probability Models (9th Edition), Academic Press, Indian Reprint, 2007.
5. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, (3rd Edition), Tata McGraw- Hill, Reprint 2007

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths

Mathematics Practical-V (Computation Mathematics with Python Programming)
Course Type: DSC

Course Objective: Student will learn about to create simple and efficient Python Codes.

Requirement:

1. You should have a good background in algebra and calculus, in addition to the basic knowledge about computers
2. A Python IDE and its libraries NumPy, matplotlib and SciPy should be installed on your computer.

The paper will contain four practicals. The candidates are required to attempt all practical.

Unit I: Find out the root of the Algebraic and Transcendental equations using Bisection, Regula-falsi and Newton Raphson Method.
Unit II: Interpolation and Curve Fitting: Lagrange's method, Newton's method, Linear Regression, Curve fitting. Numerical Differentiation and Numerical Integration by Trapezoidal, Simpson 1/3 and Simpson 3/8 rule.
Unit III: System of Linear equations: Gauss elimination method, Jacobi's method, Gauss-Seidel's Method, Gauss Jordan Method.
Unit IV: Euler method modified Euler method and Runge-Kutta method for solving ODE.

Course Outcomes: Student learns about the program of numerical methods to create simple and efficient Python codes that output the numerical solutions at the required degree of accuracy.

References

- Programming Numerical Methods in Python by Murad Elarbi
- Numerical Methods and Optimization in Python by Holczer Balazs.

Web Resources

- Programming Numerical Methods in Python | Udemy
- Computers, Waves, Simulations: A Practical Introduction to Numerical Methods using Python | Coursera

B.SC. (MATHS) VI SEMESTER

DSE D: Linear Algebra
Course Type: DSE

Prerequisite: Student should know about the basic knowledge of vector space.
Course Objective: The objective of this course is to introduce the fundamentals of linear algebra.

UNIT I: Linear Transformations, Nullity and rank, Sylvester Law of Nullity, Singular and nonsingular transformations, linear operator, invertible operator, quotient transformation.
UNIT II: Matrix Algebra, Matrix representation of transformation, Matrix representation of linear operators, Change of Basis, Similar matrices, Similarity of Linear map, determinant of a map.
Unit III: Dual Space, Linear functional, dual basis, Natural Mapping and reflexivity, Annihilator, Transpose of a linear map.
UNIT IV: Bilinear form, Symmetric and antisymmetric forms, quadratic form, matrix representation, degenerate and non-degenerate form, Projection and Invariance.

Course Outcome: After studying this course, you should be able to understand the concepts of linear transformation and their properties, Matrix representation of transformation, Dual Basis and bilinear forms.

Reference Books:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
2. Joseph A. Gallian, Contemporary Abstract Algebra (4th Edition), Narosa Publishing House, New Delhi, 1999.
3. S Lang, Introduction to Linear Algebra (2nd edition), Springer, 2005 2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007
4. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
5. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra 2nd Ed., Prentice-Hall Of India Pvt. Limited, 1971

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE D: Operation Research-II
Course Type: DSE

Prerequisite: The student must have the knowledge of optimization technique and basic statistics.
Course Objective: The main aim of the course is to plan, Schedule and Control the given project. Understand the need of inventory management and choose the appropriate queuing model for a given practical application.

Unit- I: Network Scheduling by PERT/ CPM, Simulation, Types of Simulation, Monti-Carlo Technique, and Generation of Random Variable.
Unit II: Queuing Theory – Introduction, Probability distributions in queuing systems. Models-(M/M/1) :(∞/FCFS), (M/M/1) :(N/FCFS), (M/M/s) :(∞/FCFS), (M/M/s): (N/FCFS).
Unit III: Inventory Models-Deterministic models, The Economic Order Quantity (EOQ) model, Sensitivity analysis, price-break Model.
Unit IV: Inventory Models-Probabilistic Inventory models, Single-period inventory models, fixed order quantity model, fixed time period model.

Course Outcome: After completion of the course, the student will be able to formulate Network models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these Network problems.

Reference Books:

1. Kanti Swaroop, P. K. Gupta and Man Mohan: Operation Research. Sultan Chand.
2. Operation Research – S. D. Sharma.
3. Operation Research - Models and methods by Chandrasekar Salimath, Bhupendar Parashar.
4. Operation Research – Taha.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE E: Number Theory
Course Type: DSE

Prerequisite: The student must know the basic knowledge of divisibility, GCD and HCF of numbers.
Course Objective: In this paper, Student will learn about the Euclid's algorithm, congruence, residue classes and the theory of quadratic residue

UNIT I: Divisibility - Division Algorithm, the Greatest Common Divisor, Euclidean algorithm. Greatest Common Divisor of more than two integers, least common multiple, least common multiple of n integers. Number theoretic functions, the multiplicative function. The function ζ & σ, The Mobius function, Greatest integer function, Euler's Φ function, properties of Φ function.
UNIT II: Prime Numbers, Infinitude of primes, Fundamental theorem of Arithmetic. The sieve of Eratodhenes, the Goldbach conjecture, Composite numbers having primitive roots, Fibonacci sequence.
UNIT III: Congruence, properties of Congruence, Linear congruence, Chinese remainder theorem. Congruence of higher degree. Linear Diophantine equations, the equations - ax + by = c, ax + by + cz = d, The Diophantine equation $X^2 + Y^2 = Z^2$, $X^4 + Y^4 = Z^4$, General integral solution of the equation $X^2 + Y^2 + Z^2 = W^2$, (X,Y,Z,W)=1
UNIT IV: Quadratic Residues, Elementary properties, Legender symbols, Quadratic Reciprocity Law, Quadratic Congruence. Fermat's Factorization Method, Fermat's little theorem, Fermat's Last theorem, Wilson theorem, Euler's Factorization Method, Mersenne's Factorization Method.

Course Outcome: After completion of the course students are expected to be able to:

1. Find quotients and remainders from integer division
2. Apply Euclid's algorithm and backwards substitution
3. Understand the definitions of congruence, residue classes and least residues add and subtract integers, modulo n, multiply integers and calculate powers, modulo n
4. Determine multiplicative inverses, modulo n and use to solve linear congruence.
5. Understand the theory of quadratic residue

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. David M. Burton, Elementary Number Theory 6th Ed., Tata McGraw-Hill Edition, Indian reprint, 2007.
2. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, Applications of Abstract Algebra with Maple, CRC Press, Boca Raton, 2000.
3. Neville Robinns, Beginning Number Theory, 2nd Ed., Narosa Publishing House Pvt. Limited, Delhi, 2007.
4. Hari Kishan, Number Theory, Krishna Prakashan Media (P) Ltd. India.

Online resources: https://www.coursera.org/ , https://www.khanacademy.org/ , https://alison.com/tag/maths

DSE E: Theory of Equations
Course Type: DSE

Prerequisite: The student must know the basic knowledge of algebraic equation and its roots.
Course Objective: The goal of this paper is to acquaint students with certain ideas about the general properties of roots of polynomial equations with some applications

Unit I: General properties of polynomials, Graphical representation of polynomials, maximum and minimum values of polynomials, General properties of equations.
Unit II: Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations. Symmetric functions, Applications symmetric function of the roots.
Unit III: Transformation of equations. Solutions of reciprocal and binomial equations.
Unit IV: Algebraic solutions of the cubic and biquadratic. Cardon and Ferrari method, Properties of the derived functions.

Course Outcome: After completion of this paper, the students will be able to understand the properties of roots of polynomial equations.

Reference Books:

1. W.S. Burnside and A.W. Panton, the Theory of Equations, Dublin University Press, 1954.
2. C. C. MacDuffee, Theory of Equations, John Wiley & Sons Inc., 1954.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE F: Mechanics
Course Type: DSE

Prerequisite: The student must know the basic knowledge of parallel forces and moments.

Course Objective: In this paper, student will learn about coplanar forces, friction, catenary, central orbit and the properties of collision of elastic bodies.

UNIT I: Coplanar Forces, General conditions of equilibrium of rigid body under several coplanar forces. Common catenary.
UNIT II: Friction and Virtual Work.
UNIT III: Motion Under Inverse Square law and other law of forces, Central orbits p-r equations, Apses, Time in an orbit, Kepler's laws of planetary motion
UNIT IV: Collision of elastic bodies, direct impact, oblique impact, impact on an inclined plane, Kinetic Energy lost by impact.

Course outcome: After successful completion of this paper, student will able to understand the properties of forces acting on static bodies. They also able to calculate the differential equation of central orbits for different forces.

Reference Books:

1. A.S. Ramsay, Statics, CBS Publishers and Distributors (Indian Reprint), 1998.
2. A.P. Roberts, Statics and Dynamics with Background in Mathematics, Cambridge University Press, 2003.
3. P.N. Chatterjee, Dynamics, Rajhans Publication.

Learner support Material: Swayam (https://swayam.gov.in), E-library, E-books, online PDF material etc.

Online resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

DSE F: Vector Calculus
Course Type: DSE

Prerequisite: The student must know the basic knowledge of vector algebra.
Course Objective: The primary objective of this course is to introduce the basic tools of vector calculus and basic properties of vectors as Differentiation and Integration which are helpful understand their applications to the real world problems.

Unit I: Differentiation of Vectors, Theorems on derivatives of constant vectors, Velocity and Acceleration, Scalar point function, Vector point function, Directional Derivative.
Unit II: Differential Operators: Del, Gradient, Divergence, Curl and their Identities. Tangent line, Normal line, Tangent plane and Normal plane.
Unit III: Integration of vectors, Vector line integral, Surface integral and volume integral.
Unit IV: Gauss's theorem, Stoke's theorem and Green's theorem (Without proof) and their simple applications.

Course Outcome: Students will able to understand the

1. Derivatives of vectors and their properties
2. Various operators and their applications in vector calculus
3. The concept of line, surface and volume integration with their relationship.

Learner support Material: Swayam(https://swayam.gov.in), E-library, E-books, online PDF material etc.

Reference Books:

1. Murray Spiegel, Seymour Lipschutz and Dennis Spellman, 2009 (Second Edition), "Vector Analysis", Schaum's Outline, New Dehli.
2. Shanti Narayan, 1987 (First Edition), "A tText Book of Vector Calculus", S Chand Publisher, New Dehli.
3. Sharma and Vasishtha, 2000 (Fourth Edition), "Vector Calculus", Krishna Educational Publisher, Meerut.
4. Bhapkar, Mittal 1995(First Edition), "Vector Calculus & Linear Algebra, Technical Publication, New Dehli.
5. R A Vasistha, 1995 (First Edition), "Vector Calculus", Krishna Publication, Meerut.

Online Resources: https://www.coursera.org/, https://www.khanacademy.org/, https://alison.com/tag/maths.

Mathematics Practical-VI (Numerical Methods with R Programming)

Course Objective: This course introduces R, which is a popular Mathematical/ Statistical programming language. The course covers data reading and its manipulation using R, which is widely used for numerical calculation internationally. The course also covers different control structures and design of user-defined functions.

The paper will contain four practicals. The candidates are required to attempt all practical.

Contents

Introduction: R interpreter, Introduction to major R data structures like vectors, matrices, arrays, Variables in R, Control Structures.

Installing, loading and using packages: Read/write data from/in files, converting types of values, using string in-built functions.

Unit I: Find out the root of the Algebraic and Transcendental equations using Bisection, Regula-falsi and Newton Raphson Methods by using R-script.

Unit II: Implementation of Newton's forward and backward Interpolation formula and Lagrange's Interpolation formula by using R-script. Numerical Differentiation by using R-script.

Unit III: Using R-script to implement numerical integration by Trapezoidal, Simpson 1/3 and Simpson 3/8 rule.

Unit IV: Using R-script to implement Euler method, modified Euler method and Runge-Kutta method for solving ODE.

Course Outcomes: At the end of the course, students should be able to develop an R script and execute it numerically. They can also visualize and summarize the data.

References

- Cotton, R., Learning R: a step by step function guide to data analysis. 1st edition. O'reilly Media Inc
- Gardener, M. (2017). Beginning R: The statistical programming language, WILEY
- Lawrence, M., & Verzani, J. (2016). Programming Graphical User Interfaces in R. CRC press. (ebook)

Web Resources

- https://jrnold.github.io/r4ds-exercise-solutions/index.html
- https://www.r-project.org/
- https://cran.r-project.org/