MAHARAJA GANGA SINGH UNIVERSITY, BIKANER

Syllabus

Choice Based Credit System (CBCS)

MA/MSc **Mathematics** (Semester Scheme)

SEMESTER SCHEME

- Semester I Dec 2025
- Semester II June 2026
- Semester III Dec 2026
- Semester IV June 2027

MA/MSc Mathematics Programme:

Course description:

The MA/MSc. academic programme is conducted under a semester-based examination system.

The coursework comprises lectures, seminars, and class tests/assignments.

The complete program spans **four semesters** over a **two-year duration**.

A semester-wise layout of the curriculum is provided below.

Question paper pattern

Each theory course is structured into five units. The question paper is divided into three sections: A, B, and C, with a total of 80 (or 120) maximum marks.

Section A contains 10 compulsory questions, each carrying 2 (or2) marks. Questions I to V are multiple-choice, while questions VI to X are of the fill-in-the-blank type.

Section B includes 5 questions, one from each unit. Each question carries 6 (or 8) marks. There is an internal choice provided for each question, and candidates are required to attempt all five questions.

Section C also comprises 5 questions, one from each unit. Candidates must attempt any three out of these five questions. Each question in this section carries 10 (or 20) marks.

To pass the semester, a candidate must secure a minimum of 25% marks in each individual course, internal and external examination separately, and an overall aggregate of at least 36%.

Programme Objectives:

The MA/MSc. Mathematics programme's main objectives are:

- Develop mathematical aptitude and the ability to think abstractly.
- Develop the ability to read, follow and appreciate mathematical text.
- Develop the ability to put mathematical ideas in a clear and effective manner
- Develop computational abilities and programming skills.
- Develop the ability to apply the theoretical knowledge to solve problems.
- Develop the ability to use document preparing software LaTeX.

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Programme Outcomes:

On successful completion of MA/MSc Programme in Mathematics, the students will:

- Have a strong foundation in core areas of Mathematics, both pure and applied.
- Develop strong analytical and problem-solving skills, enabling them to tackle complex mathematical problems in academic, industrial, or research settings.
- Succeed in various national level exams such as NET-JRF, GATE, NBHM etc. for higher education and other competitive exams.
- To do research, formulate mathematical models, and critically analyze findings.

Semester I Dec 2025

Course code	Course title	L	T	P	Credit	Max. marks		Min. pass marks	
						Internal	External	Internal	External
MAT6.0AECT101	Book Review				2	-`	-	Non CGPA-S/NS*	
MAT6.0DCCT102	Advanced Abstract Algebra	6	-	-	6	30	120	8	30
MAT6.0DCCT103	Advanced Complex Analysis	6	-	-	6	30	120	8	30
MAT6.0DCCT104	Special Functions	6	-	-	6	30	120	8	30
MAT6.0DCCT105	Numerical Analysis	6	-	-	6	30	120	8	30
Total Credits = 26 Total Marks = 600									

L: Lecture, T: Tutorial, P: Practical

DCC: Discipline centric compulsory course. AEC: Ability Enhancement course.

Non-CGPA Courses are practice based courses having 2 Credits and assessed internally on the basis of continuous internal assessment (no examination will be conducted by the University). The college will send the Satisfactory (S) or Not Satisfactory (NS) credentials of the student to the University.

S/NS*=Satisfactory or Not satisfactory.

Scheme of examination

Course code	Duration In hours	Maximum marks Internal/ External	Credits
MAT6.0AECT101		Non CGPA	2
MAT6.0DCCT102	03	30/120	6
MAT6.0DCCT103	03	30/120	6
MAT6.0DCCT104	03	30/120	6
MAT6.0DCCT105	03	30/120	6
Total Credits = 26 Total Marks = 600			

Note: Internal assessment is a continuous assessment and will be done on the basis of class room activities, test/assignment submission, seminar and viva-voice.

DETAILED SYLLABUS

MAT6.0AECT101

Book Review

Successful fulfilment of one of the following two shall be considered as the completion of AEC.

1. Class room seminar: One seminar based on the topics in mathematics beyond the prescribed syllabus.
2. Book review of any Mathematics text book.

MAT6.0DCCT102

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: To introduce the concepts of Group theory, Field theory and Module theory and to develop working knowledge on homomorphism, isomorphism, Jordan-Holder theorem, Sylow's theorem, normal series, composition series, Solvable group, Nilpotent group, Euclidean ring, polynomial ring, unique factorization domain, ring with chain conditions, direct sum, product of modules, free modules.

Course Learning Outcomes: After doing this course student will be able to

- Analyze various algebraic structures and associated properties.
- Demonstrate a thorough understanding of direct sum of groups, modules.
- Examine the concepts of commutators, derived subgroups, normal series,
- and apply Jordan-Hölder theorem to categorize and refine group structures.
- Understand finite groups using Sylow's theorem.
- Use Sylow's theorem to determine whether a group is simple or not.
- Understand and determine if a group is solvable, nilpotent or not.
- Understand Euclidean ring and polynomial rings
- Understand if a polynomial is reducible or irreducible over different fields.
- Understand modules, free modules.

ADVANCED ABSTRACT ALGEBRA

Unit I

Homomorphism and Isomorphism theorems on groups, conjugate elements. Conjugate classes and class equation of a finite group,

Unit II

Direct Products, Sylow Theorem, p - Sylow subgroup, structure theorem for finite abelian groups.

Unit III

Normal and subnormal series, Composition series, Jordan-Holder Theorem, Solvable group, Nilpotent groups.

Unit IV

Euclidean and polynomial rings, Polynomials over rational fields. The Eisenstein criterion, Polynomial rings over commutative ring, unique factorization domain, Rings with chain conditions.

Unit V

Basic concepts of Module theory, direct product and direct sum of modules, free modules, modules over PID's.

Books Recommended for Reference:

1. MacLane and Birkhoff: Algebra, Macmillan & Co.
2. I.N. Herstein: Topics in Algebra, Wiley Eastern India Ltd.
3. I.S. Luthar and B.S. Passi: Algebra Vol-I Groups, Vol-II Rings, Narosa Publishing House.
4. Gokhroo et.al.: Advanced Abstract Algebra, Navkar Prakashan, Ajmer
5. Bhattacharya, P.B. etc.: Basic Abstract Algebra (II ed.) Camb. Univ. Press India, 1997
6. P.M. Cohn: Algebra vol I, II & III, John Wiley & Sons, 1982-89, 91
7. Vivek Sahai & Vikas Bist: Algebra, Narosa Publishing, 1999
8. Gopala Krishnan, N.S. (II ed.): University Algebra, New Age International Publication,
9. B.S. Vatsa: Modern Algebra, 1999 New Age International Publication.

MAT6.0DCCT103

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: To introduce the concepts of:

- Region of convergence for the power series of analytic function.
- Notion of line and contour integral and their integral for an analytic function.
- Concept of a Residues and its application in evaluating real integral.

- Concept of analytic continuation.

Course Learning Outcomes: After doing this course student will be able to

- Understand Complex integration and its properties such as Taylor's series, Laurent's series, maximum modulo principle, Schwarz lemma etc.
- Find the number of zeros in a region for an analytic function.
- Evaluate the real integral with the help of Cauchy's residue theorem.

ADVANCED COMPLEX ANALYSIS

Unit I

Differentiability and analyticity of a complex function, Cauchy-Reimann equations, Harmonic functions, Power series of an analytic function, Radius of convergence of power series, sum functions of power series, Cauchy-Hadamard theorem.

Unit II

Complex line integral, Cauchy-Goursat theorem, Cauchy integral formula and its properties, Morera theorem, Taylor's theorem, Laurent series.

Unit III

Maximum modulus principle, Schwarz lemma, Liouville's theorem, zeros of analytic function, Classification of singularities.

Unit IV

Calculus of residues, Residue theorem, Meromorphic functions, principle of argument, Rouche's theorem.

Unit V

Evaluation of Integrals, Direct analytic continuation, Analytic continuation via Reflection.

Books recommended for Reference:

1. S. Ponnusamy: Foundation of Complex Analysis, Narosa Publishing House, New Delhi.

2. Shanti Narain: Complex Analysis, S. Chand & Co., New Delhi;
3. R.V. Churchill & J.W. Brown: Complex Variables and Applications, McGraw-Hill.
4. L.V. Ahlfors: Complex Analysis, McGraw Hill Co., 1979.
5. Gokhroo et.al: Complex Analysis, Navkar Prakashan, Ajmer.
6. K.P. Gupta: Complex Analysis, Krishana Prakashan Mandir, Meerut.
7. B. Choudhary: Complex Analysis, Wiley Eastern Ltd. New Delhi.
8. Purohit and Goel: Complex Analysis, Jaipur Publishing House, Jaipur.
9. S.K. Sharma etc.: Complex Analytic Functions Theory and Applications, New Age International Publishers.

MAT6.0DCCT104

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: To introduce the learners to some special functions such as Bessel functions, Legendre's polynomial, Hermite polynomials, Laguerre polynomials, Jacobi polynomials, and Chebyshev polynomials. Students will explore their definitions, properties, applications, and the role these functions play in solving differential equations and in various other fields of applied mathematics and engineering.

Course Learning Outcomes: After doing this course student will be able to

- Define and analyze Gauss hypergeometric function, Bessel functions, their properties, applications.
- Understand and apply Legendre's polynomial and associated Legendre's polynomial, Hermite polynomials, Laguerre polynomials, Jacobi Polynomials and Chebyshev Polynomials and their relevance in other fields.
- Apply special functions to solve problems in differential equations and other applied mathematics contexts.

SPECIAL FUNCTIONS

Unit I

Series solution of Gauss hypergeometric equation, Gauss hypergeometric function and its properties, integral representation, contiguous function relations, Kummer's Confluent Hypergeometric Functions.

Unit II

Legendre's polynomial, generating function, recurrence relations, orthogonal properties, Beltrami's result, Legendre function of first and second kind, Associated Legendre's functions.

Unit III

Bessel's differential equation and its solution, Bessel's functions. Recurrence relations. Orthogonal properties. Rodrigue's formula, modified Bessel function. Integral representation of Bessel's function.

Unit IV

Hermite Polynomial, their generating function and general integral properties, recurrence formulae, Rodrigue's formula, orthogonality. Lagurre polynomials and functions, their generating function and general integral properties. Rodrigue's formula, orthogonal expansion of polynomials.

Unit V

Jacobi Polynomial, Generating Function, Rodrigues formula, orthogonality of Jacobi Polynomial, Chebyshev Polynomial, Generating Function of Chebyshev Polynomial, Orthogonal Properties of Chebyshev Polynomial.

Books Recommended for Reference:

1. Rainville E.D.: Special Functions chapter: 1, 6, 8, 11 & 12.
2. Slater L.J.: Confluent Hypergeometric Functions, Cambridge University Press. 1966.
3. L.J. Slater: Generalized Hypergeometric Functions, Cambridge University Press, 1966.
4. Gokhroo et.al: Special Functions, Navkar Prakashan, Ajmer.
5. Saran et al; Special Functions, Pragati Prakashan, Meerut.

MAT6.0DCCT105

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: Make the learners aware of numerical methods for solving algebraic and differential equations.

Course Learning Outcomes: After doing this course student will be able to:

- Understand and apply iterative methods, including the theory of iteration, acceleration of convergence.
- Solve polynomial equations by the Birge-Vieta method, Bairstow's method, and Graffe's root squaring method.
- Solve Systems of Simultaneous Linear Equations using Gauss elimination, Gauss Jordan, Cholesky, Partition methods of successive, Jacobi iteration method, Gauss-Seidel iteration & Relaxation methods.
- Understand Eigen value problem and finding eigen values and eigen vectors.
- Understand curve fitting and function approximation and applying to the problems.

NUMERICAL ANALYSIS

Unit I

Iteration methods: Simple iteration, theory of iteration, acceleration of convergence, methods for multiple and complex roots, Newton Raphson method, convergence of iteration process in the case of several unknowns.

Unit II

Solution of polynomial equations: polynomial evaluation, real and complex roots, synthetic division, the Birge-Vieta method, Bairstow and Graffe's root squaring.

Unit III

Solution of simultaneous equations: Gauss elimination, Gauss Jordan, Cholesky, Partition methods of successive, Jacobi iteration method, Gauss-Seidel iteration & Relaxation methods. Eigen value problem: Jacobi and Given's method for symmetric, power methods for finding all eigen pairs of a matrix, complex eigen values.

Unit IV

Curve fitting and function approximation, least square approximation, error criterion, linear regression, polynomial fitting and other curve fitting, approximation of functions by Taylor series and Chebyshev polynomials.

Unit V

Numerical solution of ordinary differential equations, Taylor series methods, Euler's and modified Euler's method, Runge-Kutta method up to fourth order, multi-step method (Predictor -Corrector Strategies).

Note: Use of non-programmable scientific calculator is allowed in theory examination.

Books Recommended for Reference:

1. Jain, Iyengar & Jain: Numerical Analysis
2. Jain M.K.: Numerical Solution of differential equations
3. Gokhroo et. al.: Advanced Numerical Methods, Navkar Prakashan, AJMER.

SEMESTER II JUNE 2026

Course code	Course title	L	T	P	Credit	Max. marks		Min. pass marks	
						Internal	External	Internal	External
MAT6.0VACT201	Ancient Indian Mathematicians				2	-`	-	Non CGPA-S/NS*	
MAT6.0DCCT202	Advanced Linear Algebra	6	-	-	6	30	120	8	30
MAT6.0DCCT203	Measure Theory and Integration	6	-	-	6	30	120	8	30
MAT6.0DCCT204	Integral Transforms	6	-	-	6	30	120	8	30
MAT6.0DCCT205	Optimization techniques	6	-	-	6	30	120	8	30
					Total Credits= 26			**Total marks = 600**	

L: Lecture, T: Tutorial, P: Practical

DCC: Discipline centric compulsory course. VAC: Value added course.

Non-CGPA Courses are practice based courses having 2 Credits and assessed internally on the basis of continuous internal assessment (no examination will be conducted by the University). The college will send the Satisfactory (S) or Not Satisfactory (NS) credentials of the student to the University.

S/NS*=Satisfactory or Not satisfactory.

Scheme of examination:

Course code	Duration In hours	Maximum marks Internal/ External	Credits
MAT6.0VACT201		Non-cgpa	2
MAT6.0DCCT202	03	30/120	6
MAT6.0DCCT203	03	30/120	6
MAT6.0DCCT204	03	30/120	6
MAT6.0DCCT205	03	30/120	6
Total credits = 26		**Total Marks= 600**	

Note: Internal assessment is a continuous assessment and will be done on the basis of class room activities, test/assignment submission, seminar and viva-voice.

MAT6.0VACT201

Ancient Indian Mathematicians

The student's performance will be judged on the basis of their participation in seminar and poster presentation on the contribution of ancient Indian mathematician.

MAT6.0DCCT202

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: To introduce learners the concept of

- Representing linear transformation as a matrix.

- Linear functionals, dual basis and the dual (or transpose) of a linear transformation.
- Inner product, norm, Cauchy-Schwarz inequality, and orthogonality on real or complex vector spaces.
- Diagonalization problem and canonical forms for linear operators or matrices using eigenvalues.
- Characterization of self-adjoint (or normal) operators on real (or complex) spaces in terms of orthonormal bases of eigenvectors and their corresponding eigenvalues.

Course Learning Outcomes: After doing this course student will be able to

- Understand the notion of an inner product space and how the notion of inner products can be used to define orthogonal vectors.
- Understand how a set of vectors can be orthogonalize.
- Use eigenvectors and eigenspaces to diagonalize a linear operator.
- Find the Jordan canonical form of matrices.

ADVANCED LINEAR ALGEBRA

Unit I

Vector space of a linear transformation, Matrix representation of a linear transformation, Change of basis, Similarity, Eigen value and eigenvectors for a linear operator.

Unit II

Linear functionals, Dual and bidual of a vector space and their properties, Invariance, projections and its properties, Adjoint of a linear transformation and its properties.

Unit III

Inner product spaces, Orthogonality, Gram-Schmidt orthogonalization process, ortho-normal sets and bases, Bessel's inequality for finite dimensional spaces, Canonical forms.

Unit IV

Diagonalization, Minimal Polynomial and equation, Bilinear, Quadratic, Hermitian forms and their properties

Unit V

Linear operators on Inner product spaces, Adjoint operators, self-adjoint operators, orthogonal and unitary operators, normal operator, spectral theorem.

Books Recommended for Reference:

1. Hofman and Kunz.: Linear Algebra, Prentice Hall of India.
2. K.B. Datta: Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi.
3. Gokhroo et.al: Advanced Linear Algebra, Navkar Prakashan, Ajmer
4. Purohit, Pareek, Sharma: Linear Algebra, Jaipur Publishing House
5. P.M. Cohn: Algebra vol I, II & III, John Wiley & Sons, 1982-89, 91
6. Gopala Krishnan, N.S. (II ed.): University Algebra New Age International Publication
7. B.S. Vatsa: Modern Algebra, 1999 New Age International Publication.

MAT6.0DCCT203

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: The objective of this course is to provide students with a comprehensive understanding of advanced concept of measure in real analysis. Through a systematic exploration of measurable sets and measurable functions, the students will gain the necessary knowledge for work in Lebesque measure and integration.

Course Learning Outcomes: After doing this course student will be able to

- Verify whether a given subset of a real number is countable.
- Understand whether a given subset of a real valued function is measurable.
- Understand the requirement and the concept of the Lebesgue integral, as a generalization of the Reimann integral, along its properties.
- Understand the statement and proofs of the fundamental integral convergence theorems and their applications.
- Understand the concepts of functions of finite variations .
- Understand the concepts of summable and square summable functions.

MEASURE THEORY AND INTEGRATION

Unit I

Countable sets. Outer measure of a set and its properties. Measurable sets. Lebesgue measure. Non-measurable sets.

Unit II

Measurable functions and their properties. Sequences of measurable functions. Convergence of sequence of measurable functions, The structure of measurable functions, Littlewood's three principles.

Unit III

Lebesgue integral of a bounded function, Properties of the Lebesgue integral for bounded measurable functions, theorem on the passage to the limit under the integral sign.

Unit IV

Summable functions, Square summable functions.

Unit V

Function of finite variation, The indefinite Lebesgue integral.

Books Recommended for Reference:

1. T.M. Apostal: Mathematical Analysis, Narosa Publishing House, New Delhi (1985)
2. P.K. Jain and V.P. Gupta: Lebesgue Measure and Integration, New Age International Pub. Ltd., New Delhi (Reprint 2000)
3. G.N. Purohit: Lebesgue Measure and Integration, Jaipur Publishing House, Jaipur
4. T.S. Nahar: Measure Theory, Navkar Publications, Ajmer.
5. Indra Kumar Rana: An Introduction to Measure and Integration,
6. Narosa Publishing House, New Delhi (1997)
7. G-de Barra, Gupta: Measure Theory and Integration, Wiley Eastern Ltd.

MAT6.0DCCT204

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: The main objective of this course is to provide the learners the idea of integral transforms of functions and their applications in solving differential equations and analyzing functions. Laplace transform, Fourier transform, Mellin and Hankel's transform are covered in the course.

Course Learning Outcomes: After doing this course student will be able to

- Compute Laplace transform, Fourier transform, Mellin and Hankel's transform of classes of functions.
- Understand and apply the definition and properties of Laplace transform, Fourier transform, Mellin and Hankel's transform.
- Apply techniques of these transforms to solve ordinary and partial differential equations and initial and boundary value problems.

INTEGRAL TRANSFORMS

Unit I

Laplace Transforms: Definition and properties, Existence conditions for Laplace transform, Laplace Transform of derivatives and integrals, multiplication and division by powers of x, periodic functions, initial and final value theorem, Inverse Laplace Transform of derivatives, integrals, convolution of two functions, Convolution theorem, Complex inversion formula.

Unit II

Application of Laplace Transform for the solution of ordinary differential equations with constant and variable coefficient, Simultaneous ordinary differential equations. Partial differential equations, Integral and difference equations,

Unit III

Fourier Transform: Fourier Sine and Cosine transform, Inverse Fourier Transform, Convolution Theorem. Fourier transform of derivatives.

Unit IV

Application of Fourier Transform in the solution of boundary value problems, partial differential equations.

Unit V

Hankel Transform: Definition and Elementary properties: Inverse theorem Hankel Transform of derivatives. Parseval's Theorem. Mellin Transform: Properties and integrals. Application of Hankel Transform in the solution of boundary value problems.

Books Recommended for Reference:

1. Sneddon I.N.: The use of integral Transforms, McGraw Hill Co., 1966
2. Spegal M.R.: Theory and problems of Laplace transform, Schaum Series, TMH
3. Gokhroo et. al: Integral Transform, Navkar Prakashan, Ajmer.
4. Vasishtha et. al.: Integral Transforms, Krishna Prakashan Mandir, Meerut
5. M.D. Raisinghania: Integral Transforms, Kedar Nath Ram Nath, Meerut.

MAT6.0DCCT205

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: Make the learners aware of linear programming problem(lpp), various methods to solve the lpp problems and optimization techniques.

Course Learning Outcomes: After doing this course student will be able to

- Formulate the problem and solve it by graphical method,
- Solve linear programming problems by using simplex method, revised simplex method, two phase method and Big M method.
- Understand duality concept and its use in solving lpp.
- Solve transportation and assignment problems.
- Know CPM and PERT for project scheduling.
- Understand the use of game theory in daily life.

OPTIMIZATION TECHNIQUES

Unit I

Linear programming problem: Mathematical formulation, Graphical solution method, Theory of Simplex method.

Unit II

Two Phase method, Big- M method, Revised simplex method Duality in linear programming,

Unit III

Transportation problem: Definition, Formulation and solution of transportation problem, Initial Basic Feasible solution, Test for optimality, degeneracy in transportation problem.

Unit IV

Assignment problem, Introduction, Mathematical formulation of the problem, solution methods of Assignment problems.

Network Scheduling by PERT/ CPM, Introduction, Network and basic components, logical sequences, Rules of Network constructions, Critical path Analysis.

Unit V

Games theory, Introduction, Characteristics of Games theory, Definitions, Minimax and Maximin criterion of optimality, Solution of games with and without saddle points, equivalence of rectangular game and linear programming, solution of, games by Simplex method, Arithmetic method, Graphical method, Matrix method, Algebraic method, iterative method, Concept of dominance and related problems.

Book Recommended for Reference:

1. G. Hadley: Linear Programming
2. Gokhroo et al: Operations Research, Navkar Publishers
3. T.L. Saaty: Mathematical Methods of Operational Research
4. Sasieni, Friedman and Yaspan: Operations Research
5. P.K. Gupta & Man Mohan: Operations Research, Sultan Chand & Sons, New Delhi.

6. Kanti Swarup, P.K. Gupta & D. S. Hira: Operations Research-An Introduction, S. Chand & Company Ltd., New Delhi.

SEMESTER III Dec2026

Course code	Course title	L	T	P	Credit	Max. marks	Min. pass marks		
						Internal	External	Internal	External
MAT6.5SDC301	Mathematical Documentation with Latex				2	-`	-	Non CGPA- S/NS*	
MAT6.5DCCT302	Differential Equations	6	-	-	6	30	120	8	30
MAT6.5DCCT303	General Topology	6	-	-	6	30	120	8	30
Any three of the following									
MAT6.5DCET304	Tensor Analysis	4			4	20	80		
MAT6.5DCET305 (**Course** MAT6.5DCET304 is compulsory for this course)	Relativistic mechanics (Course MAT6.5DCET304 is compulsory for this course)	4	-	-	4	20	80	5	20
MAT6.5DCET306	Dynamics	4	-	-	4	20	80	5	20
MAT6.5DCET307	Operation research	4	-	-	4	20	80	5	20
MAT6.5DCET308	Discrete Mathematics	4	-	-	4	20	80	5	20
MAT6.5DCET309	Mathematical Modelling	4	-	-	4	20	80	5	20
MAT6.5DCET310	Programming in Python (Theory)	4	-	-	4	20	80	5	20
MAT6.5DCEP311	Programming in Python (Practical)	-	-	4	4	20	80	5	20

Course code	Course title	L	T	P	Credit	Max. marks		Min. pass marks	
						Internal	External	Internal	External
(**Course** MAT6.5DCET310 is compulsory for this course)	(**Course** MAT6.5DCET310 is compulsory for this course)								
Total Credits=26 Total Marks=600									

L: Lecture, T: Tutorial, P: Practical

DCC: Discipline centric compulsory course. SDC: Skill development course.

Non-CGPA Courses are practice based courses having 2 Credits and assessed internally on the basis of continuous internal assessment (no examination will be conducted by the University). The college will send the Satisfactory (S) or Not Satisfactory (NS) credentials of the student to the University.

S/NS*=Satisfactory or Not satisfactory.

Scheme of examination:

Course code	Duration In hours	Maximum marks Internal/ External	Credits
MAT6.5SDC301		Non-cgpa	2
MAT6.5DCCT302	03	30/120	6
MAT6.5DCCT303	03	30/120	6
Any three of the following			
MAT6.5DCET304	03	20/80	4
MAT6.5DCET305 (Course MAT6.5DCET304 is compulsory for this course)	03	20/80	4
MAT6.5DCET306	03	20/80	4
MAT6.5DCET307	03	20/80	4

Course code	Duration In hours	Maximum marks Internal/ External	Credits
MAT6.5DCET308	03	20/80	4
MAT6.5DCET309	03	20/80	4
MAT6.5DCET310	03	20/80	4
MAT6.5DCEP311 (**Course** MAT6.5DCET310 is compulsory for this course)	03/	20/80	4
Total Credits= 26 Total Marks = 600			

Note: Internal assessment is a continuous assessment and will be done on the basis of class room activities, test/assignment submission, seminar and viva-voice.

MAT6.5SDC301

Mathematical Documentation with Latex

The objective of this course is to introduce the learners about the LaTeX software, its coding and in preparing a Report. Successful completion of the course will be judged on the basis of performance of the document prepared through LaTeX.

MAT6.5DCCT302

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: The aim of this course is to enable the students to learn about the existence, uniqueness of solutions of first order ordinary differential equation. Students will explore the classification and canonical forms of second-order linear PDEs, the theory of Sturm-Liouville problems, and methods for solving both homogeneous and nonhomogeneous boundary value problems. The course will also cover Green's functions and their applications in solving differential equations.

Course Learning Outcomes: After doing this course student will be able to

- Identify and classify linear partial differential equations of second Order.

- Solve linear homogeneous boundary value problems, using the concepts of eigenvalues and eigenfunctions and Sturm-Liouville theory to establish orthogonality.
- Apply methods of eigenfunction expansion for non-homogeneous Sturm-Liouville boundary value problems
- Apply method of separation of variables to solve Laplace, wave, and diffusion equations.
- To construct and apply Green's functions for non-homogeneous boundary value problems.
- Apply Dirac delta function method and bilinear formulas for Green's functions to solve complex boundary value problems.

DIFFERENTIAL EQUATIONS

Unit I

The Lipschitz condition, Existence and uniqueness of solution of dy/dx = f (x,y) and related problems.

Unit II

Classification of second order PDE, Canonical forms, Cauchy's problem for quasi- linear second order partial differential equation. Methods of characteristics.

Unit III

Linear homogeneous BVP, Eigen values and eigen functions, Sturm-Liouville BVP, Orthogonality of eigen functions, Lagrange's identity, properties of Eigen functions, important properties of Sturm-Liouville system.

Unit IV

Non-homogeneous Sturm-Liouville boundary value problem (method of eigen function expansion), Solution of Laplace, Wave and Diffusion equations by method of separation of variables.

Unit V

Non-homogeneous Sturm-Liouville BVP (method of Green's function), construction of Green's function and solution of BVP, properties of Green's function, Inhomogeneous boundary conditions, Dirac delta function, Bilinear formula for Green's function, Modified Green's function.

Books Recommended for Reference:

1. Fred A Hinchey: Introduction to Applicable Mathematics Part- II, Wiley Eastern Ltd.
2. A.N. Sneddon: Mixed Boundary Value Problem in Potential theory
3. Gokhroo et.al: Advanced Differential Equations, Navkar Prakashan, Ajmer.
4. Bansal et al; Differential Equation Volume II , Jaipur Publishing House, Jaipur.

MAT6.5DCCT303

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: To study metric space, topological spaces, continuous functions, connectedness, compactness and separation axioms.

Course Learning Outcomes: After doing this course student will be able to

- Learn how the usual idea of distance(metric) can be taken to any set of objects and this leads to the study of metric spaces.
- Understand the concept of metric space and the basic definitions of open sets, closed sets, neighborhood, interior, exterior, closure and their axioms for defining topological space.
- Understand and illustrate the concept of topological spaces and the basic definitions of open sets, neighborhood, interior, exterior, closure and their axioms for defining topological space.
- Understand continuity, compactness, connectedness, homeomorphism and topological properties.
- Analyze and apply the topological concepts in Functional Analysis.
- Ability to determine that a given point in a topological space is either a limit point or not for a given subset of a topological space.

GENERAL TOPOLOGY

Unit I

Metric spaces and their examples, Diameter of a set and bounded set, open sphere, open set, interior point of a set, limit point of a set, closed ball, closed set, convergent and Cauchy sequence, complete metric space, Cantor's intersection theorem, Baire's category theorem, Continuity in metric spaces. Contracting mapping, Fixed-point theorem.

Unit II

Topological spaces, order topology, product topology, subspace topology, metric topology, quotient topology, coarser and finer topologies, neighbourhood and neighbourhood system, equivalent definitions of topologies, basis.

Unit III

Continuity on topological spaces, open and closed functions. Homeomorphic spaces, topological properties, topologies induced by functions.

Unit IV

Compactness in topological spaces, compactness in Metric spaces, locally compact space.

Unit V

Separation axioms, regular spaces, complete regular spaces, normal spaces, complete regular spaces, connected spaces, disconnected spaces, locally connected spaces.

Books Recommended for Reference:

1. Nahar, T.S.: Metric Spaces, Navkar Prakashan, AJMER

2. Lipschutz, S.: General topology. The any problem, McGraw Hill Co. (Ch. V, VI, X, XI)

3. Gokhroo et. al.: Topology, Navkar Prakashan, AJMER

4. Simmons, G.F.: Introduction of Topology and Modern Analysis, McGraw Hill Co.

<u>CORE ELECTIVE (ANY THREE)</u>

MAT6.0DCET304

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: to introduce the concepts of Tensor analysis. Students will explore the mathematical foundations of tensors and their properties, geodesics and the curvature of Riemannian spaces. The course aims to equip students with the analytical skills necessary to apply these concepts in advanced theoretical and applied contexts, such as general theory of relativity and differential geometry**.**

Course Learning Outcomes: After doing this course student will be able to

- Understand different types of Tensors and their properties, apply the quotient law and relative tensor concepts in Riemannian spaces.
- Understand Christoffel symbols and their properties, perform covariant and intrinsic differentiation of tensors.
- Analyze Geodesics: Derive and solve the differential equations of geodesics, Geodesics Co-ordinates, Parallelism, generalized covariant derivatives.
- Explore Riemannian Curvature: Analyze the Riemann-Christoffel tensor and covariant
- Curvature tensor, understanding their properties and significance in the context of Einstein spaces and Bianchi's identity.

TENSOR ANALYSIS

Unit I

Transformation of Coordinates, Covariant, Contravariant, mixed tensor, Invariants, Addition, subtraction and multiplication of tensors. Contractions of tensors, Quotient Law of tensors.

Unit II

Metric tensor, Riemannian space, Fundamental Tensors, Length of Curve, Null curve, Associated tensors.

Unit III

Christoffel symbols, Covariant Differentiation of tensors, Laws of covariant differentiation.

Unit IV

Curvature of a curve, Geodesics, Null Geodesics, Geodesics Co-ordinates Parallelism, generalized covariant derivatives. Reimann Christoffel tensor, curvature tensor, Ricci tensor, Bianchi Reimann curvature, Flat space, space of constant curvature

Unit V

Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components, Ricci's coefficients of rotation

Books Recommended for Reference:

1. Berry Spain: Tensor Calculus.
2. Bansal J.L: Tensor Calculus, Jaipur Publishing House, Jaipur.
3. Raj Bali: Tensor Calculus, Navkar Prakashan, Ajmer.
4. Goodbody, A M: Cartesian Tensor.

MAT6.5DCET305

(**Course** MAT6.5DCET304 is compulsory for this course)

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: The aim of this course is to enable the learners grasp the principles and mathematical framework of special theory of relativity. Students will learn the foundational concepts such as the relativity of space and time, Lorentz transformations, and relativistic effects. The topic covered in the course are relativistic mechanics, time dilation, Lorentz contraction, and the relationship between mass and energy. Students will study the geometrical interpretation of relativity through Minkowski space. They understand the principles of equivalence and general covariance.

Course Learning Outcomes: After doing this course student will be able to

- Understand and apply Relativity Principles to the problems involving velocity composition, time dilation, and length contraction.
- Describe and apply concepts of simultaneity, relativistic velocity transformations, and Lorentz contraction.
- Solve problems related to particle acceleration and relativistic aberration.

- Understand the concept of variation of mass with velocity and equivalence of mass and energy.
- Apply transformation formulae for relativistic mass, momentum, energy, force and density.
- Solve problems related to the conservation of these quantities.
- Apply the principles of relativistic Lagrangian and Hamiltonian mechanics.
- Understands Minkowski Space and Relativistic Geometry.
- Apply the concepts of Minkowski space, space-like, time-like, null cone, proper time, world lines, principles of equivalence and general covariance.

RELATIVISTIC MECHANICS

Unit I

Inertial frame, Galilean Transformations, Michelson and Morely Experiment, Relative character of space and time, Principle of relativity and its postulates, Derivation of special Lorentz's transformation equations.

Unit II

Lorentz Fitzgerald Contraction formula, Simultaneity, time dilation, Proper time, Composition of parallel velocities, Relativistic formulae for composition of Accelerations Relativistic Aberration.

Unit III

Variation of mass with velocity, Equivalence of mass and energy, Transformation formulas for mass, momentum, Energy, Force and density.

Unit IV

Minkowski space, Space and time like intervals, Null Cone, World point and World line, Proper time, Relativistic Lagrangian & Hamiltonian.

Unit V

Minkowski's equation of Motion. Energy momentum four vectors. Relativity and causality. Clock Paradox. General Lorantz transformation. Principal of Covariance and principal of equivalence.

Books Recommended for Reference:

1. Satya Parkash: Relativistic Mechanics

2. Goyal et al: Theory of Relativity, Pragati Prakashan Meerut.

3. Rajbali: Theory of Relativity, Jaipur Publishing House, Jaipur

MAT6.5DCET306

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: To introduce the learners the concept of motion of a particle in a straight line and plane under varying forces.

Course Learning Outcomes: After doing this course student will be able to

- Understand Radial, transverse, normal and tangential velocity and acceleration.
- Understand simple harmonic motion and solve problems related to it.
- Derive the equation of motion of a particle under varying forces and solve problems related to it.
- Understands constrained motion and motion in resisting medium and related problems.
- Understand motion of a particle in plane and find the path of the particle.
- Understand Kepler's law of planetary motion and solve related problems.

DYNAMICS

Unit I

Velocities and acceleration along radial and transverse, tangential and normal directions, Simple harmonic motion, Recti-linear motion under various laws.

Unit II

Hook's law, related problems on horizontal and vertical elastic strings, Constrained motion, Circular and Cycloidal motion.

Unit III

Motion in Resisting medium; motion of a projectile in a resisting medium in which resistance varies as velocity, square of velocity, motion on a smooth curve under resistance, motion on a revolving curve.

Unit IV

Central forces, Central orbits, aerial velocity and linear velocity in central orbits, Laws of force and related problems, Apses and apsidal distance, problems related to the path of the particle, Differential equation of the path under radial and transverse accelerations.

Unit V

The inverse square law and related problems, Kepler's law of planetary motion, time of description of an arc of an elliptic, parabolic, hyperbolic orbit, Euler's theorem.

Books Recommended for Reference:

1.Ray, M.: Text book of Dynamics

2. Gokhroo et. al: Dynamics

3.Loney S.L.: Dynamics of Particle

MAT6.5DCET307

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: The primary objective of this course is to provide the learners a thorough understanding of linear programming problem(lpp), integer programming problem(IPP), Replacement models, Inventory and Queueing theory models and their solutions to apply them to the real time problems in Business and management.

Course Learning Outcomes: After doing this course student will be able to

- Apply Simplex method, Dual Simplex method, revised simplex method to find optimal solution.
- Perform sensitivity analysis.
- Solve IPP using Gomory's method, Branch and Bound method.
- Understands replacement problem and form replacement policy,
- Understands inventory problems, EOQ and can solve real world problem in business and management.
- Understands Queueing theory problems and solve related problems.

OPERATIONS RESEARCH

UNIT I

The theory of simplex method, Dual Simplex method, Revised simplex method, Sensitivity analysis (Post optimal solution)

UNIT II

Integer programming, Properties, Definitions, Gomory's technique, Branch and Bound technique to solve integer programming problem.

UNIT III

Replacement Problems, Introduction. Replacement policy when value of money does not change with time, Replacement policy when value of money changes with time, Replacement of equipment that fails suddenly, Group replacement policy .

UNIT IV

Inventory Control, Definitions, Costs associated with inventories, Factors affecting inventory control, An inventory control problem, EOQ concept, Deterministic inventory problems with and without shortages, EOQ problems with price breaks.

UNIT V

Queueing Theory, Queueing problem, Definitions, Classification of queueing models, Pure birth and death processes and their properties, Distribution of inter-arrival times, Queueing models: Model{ (M/M/1):(∞/FIFO)}, Model{(M/M/1) : (N/FIFO)}, {(M/M/s):(∞/$FIFO$)}.

Books Recommended for Reference:

1.G. Hadley: Linear Programming

2.Gokharoo et al: Operations Research, Navkar Publishers

3. T.L. Saaty: Mathematical Methods of Operational Research

4.Sadieni, Friedman and Yaspan: Operations Research

5. S. Vajda: Mathematical Programming

6. P.K. Gupta & Man Mohan: Operations Research, Sultan Chand & Sons, New Delhi.

7. Kanti Swarup, P.K. Gupta & D. S. Hira: Operations Research-An Introduction, S. Chand & Company Ltd., New Delhi.

MAT6.5DCET308

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: To introduce the learners the concept of Lattice, Boolean algebra, logic, language, grammars and finite state automata.

Course Learning Outcomes: After doing this course student will be able to

- Know the algebraic structures of lattices and Boolean algebra, and sketch the minimizing Boolean polynomial.
- Apply Boolean algebra techniques to model switching circuits.
- Understand and apply mathematical logic and logical operations to various fields.
- Understand language, regular expression, regular language and Finite state automata.
- Understands non-deterministic Finite State Automata, Finite State machine, Grammars and its types.

DISCRETE MATHEMATICS

Unit I

Lattices: Lattices as partially ordered sets, their properties, duality, Lattices as algebraic systems, Sub lattices, Direct products, Bounded Lattices, Complete Lattices, Complemented Lattices and Distributive lattices.

Unit II

Boolean Algebras: Boolean Algebras as lattices, Various Boolean Identities, The Switching Algebra, examples, Sub algebras, Direct products and Homeomorphisms,

Boolean forms and their Equivalence, Min-term Boolean forms, Sum of product Canonical forms, Minimization of Boolean functions.

Unit III

Formal Logic: Statements, Symbolic Representation of statements, Truth tables, Logical equivalence, Algebra of propositions, Conditional proposition, Converse, Contrapositive and Inverse, Bi-conditional Proposition, Negation of compound statement, Tautologies and contradictions, Normal forms, Predicates and Validity of arguments, Quantifiers.

Unit IV

Languages, Regular language and regular Expressions, Finite State Automata.

Unit V

Non-deterministic Finite State Automata, Finite State machine, Grammars, Phrase-Structure Grammar, context- sensitive grammar, context- free grammar, Regular Grammar.

Books Recommended for Reference:

1. Seymour Lipschutz and Marc Lars Lipson , The Theory and Problems of Discrete Mathematics, Third Edition, McGraw-Hill Book Co. New –York.
2. J. E. Hopcroft and J.D. Ullman, Introduction to Automata Theory Languages & Computation, Narosa Publishing House, Delhi,2007.
3. S.K. Sarkar, A Text book of Discrete Mathematics, S Chand and Company Ltd., 2006.
4. C. L. Liu, Elements of Discrete Mathematics, McGraw-Hill Book Co.

5. D. S. Chauhan and R. Pandey, Elements of Discrete Mathematics, Jaipur Publishing House, Jaipur.

MAT6.5DCET309

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: To introduce the learners the concept of:

- Mathematical modelling and its importance in various disciplines.
- Formulating mathematical models for real-world problems using difference equations, differential equations, proportionality and geometric similarity.
- Experimental modelling and simulation modelling.

Course Learning Outcomes: After doing this course students will be able to:

- Appreciate the concept of mathematical modelling as the representation of a system by a set of mathematical relations or equations.
- Understand its importance in various disciplines.
- Formulate mathematical models for real-world problems using difference equations, differential equations, proportionality and geometric similarity.
- Do experimental modelling.
- Do simulation modelling for checking its behaviour: deterministic or probabilistic. .

MATHEMATICAL MODELLING

Unit I

Introduction to Mathematical Modelling, Modelling Change with Difference Equations, Approximating Change with Difference Equations, Solutions to Dynamical Systems, Systems of Difference Equations.

Unit II

Introduction to Proportionality and Geometric Similarity, Mathematical Models, Modelling Using Proportionality, Modelling Using Geometric Similarity, Automobile Gasoline Mileage, Body Weight and Height, Strength and Agility.

Unit III

Introduction to Experimental Modelling, harvesting in the Chesapeake Bay and Other One-Term Models, High-Order Polynomial Models, Smoothing: Low-Order Polynomial Models, Cubic Spline Models.

Unit IV

Introduction to Simulation Modeling, Simulating Deterministic Behavior: Area Under a Curve, Generating Random Numbers, Simulating Probabilistic Behavior, Inventory Model: Gasoline and Consumer Demand, Queuing Models.

Unit V

Introduction to discrete probabilistic modelling, Modelling Component and System Reliability, Linear Regression models.

Introduction to modelling through differential equation, Population Growth model, Prescribing drug dosage model, Graphical solutions of autonomous differential equations.

Books Recommended for Reference:

1. Giordano, Frank R., Fox, William P., & Horton, Steven B. (2014). A First Course in Mathematical Modeling (5th ed.). Brooks/Cole, Cengage Learning India Pvt. Ltd.
2. Mickens, Ronald E.: Mathematical Modelling with Differential Equations, CRC Press, Taylor & Francis Group
3. Maurya R.P.: Mathematical Modelling, Navkar Prakashan, Ajmer.
4. Kapur J.N.: Mathematical Modelling, New Age Publishers, New Delhi.

MAT6.5DCET310

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: The objective of the course is to introduce to students' concept of Python programming. Students will study python coding to apply in various fields.

Course Learning Outcomes: After doing this course student will be able to write code in Python programming.

PROGRAMMING IN PYTHON(Theory)

Unit I

Python programming: An introduction, structure of a python program, understanding python interpreter, indentation, atoms, identifiers and keywords, literals, Python strings,

Basic operators: arithmetic operator, relational operator, logical or Boolean operator, bit wise operators.

Variables and Functions: Python standard libraries such as sys and math, Variables and assignment statements, built in functions.

Unit II

Control flow statements: if conditional statement and for loop, while loop, break, continue, and pass statement, else statement, infinite loop.

Functions: Function definition and call, default parameter values, keyword arguments, assert statement. Strings: Strings-slicing, membership, and built-in functions on strings.

Unit III

Lists- list operations, Mutable object, Lists-built-in functions, list, comprehension, passing list as arguments, copying list objects.

Sets, tuples and dictionary-associated operations and built-in functions.

Python 2D and 3D graphics: Visualization using graphical objects like point, line, histogram, sine and cosine curve, 3D objects.

Unit IV

File I/O handling, Reading and writing text and structured files.

Errors and exceptions: Types of errors and exceptions and exception handling

Unit V

Classes: Creating classes and objects, Method of overloading and overriding, Data hiding, Data abstraction.

Books Recommended for Reference:

1. Lutz, Mark: Learning Python, O'Reilly publication.
2. Rao, K. Nageswara, Shaikh Akbar: Python programming, Scitech publications India Pvt. Ltd.
3. Wesley J. Chun.: Core Python programming, Prentice Hall.

MAT6.5DCEP311

(**Course** MAT6.5DCET310 is compulsory for taking this course)

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: To Implement programming concepts in Python.

Course Learning Outcomes: After doing this course student will be able to:

- Write, run and debug programs using advanced concepts of Python.

PROGRAMMING IN PYTHON(Practical)

1. Write simple Python program to display message on screen.
2. Write simple Python program using operators:
   I. Arithmetic operators.
   II. Logical operators.
3. Write simple Python program to demonstrate use of conditional statements: if statement, if else statement, Nested if statement.
4. Write Python program to demonstrate use of looping statements: while loop, for loop, nested loops.
5. Write Python program to perform following operations on Lists:
   I. Create List
   II. Access list
   III. Update list

6. Write Python program to perform following operations on tuples:
    I. Create set
    II. access set
    III. update set
7. Write Python program to demonstrate math built-in function.
8. Write Python program to demonstrate string built-in functions.
9. Write a Python program to find factorial n, where n is a positive integer.
10. Write the Python program that takes a number (>=10) as an input and return the digits of number as a set.
11. Consider the tuple A= (1,2,5,7,9,2,4,6,8,10). Write a program to perform following operations:
    I. Print another tuple whose values are even numbers in the given tuple.
    II. Concatenate a tuple B={11,13,15} with A.
    III. Return maximum and minimum value from this tuple.
12. Write a python program to find the numerical solution of an equation using bisection methos, Newton Raphson method and Secant method.
13. Write a python program to find the roots of a quadratic equation.
14. Write a python program to compute multiplication of two 3x3 matrices.
15. Write a python program to compute mean and standard deviation of given array.
16. Write a python program to create a Pie chart for comparing three features.

Distribution of Marks:

Three Practical (20 Marks each) = 60 Marks

Practical Record= 10 Marks

Viva - Voce= 10Marks

Total Marks= 80 Marks

Note:

1. Each candidate is required to appear in the Practical examination to be conducted by internal and external examiner. External examiner will be appointed by the University

through BOS and internal examiner will be appointed by the Head of the Department / Principal of the College.

2. Each candidate has to prepare his / her practical record.

SEMESTER IV June 2027

Course code	Course title	L	T	P	Credit	Max. marks		Min. pass marks	
						Internal	External	Internal	External
MAT6.5AECT401	Vedic Mathematics				2	-`	-	Non CGPA-S/NS*	
MAT6.5DCCT402	Integral Equations	6	-	-	6	30	120	8	30
MAT6.5DCCT403	Functional Analysis	6	-	-	6	30	120	8	30
Any three of the following									
MAT6.5DCET404	Graph Theory	4	-	-	4	20	80	5	20
MAT6.5DCET405	Generalized Hypergeometric Function	4	-	-	4	20	80	5	20
MAT6.5DCET406	Non-linear and Dynamic Programming	4	-	-	4	20	80	5	20
MAT6.5DCET407	Continuum mechanics	4	-	-	4	20	80	5	20
MAT6.5DCET408	Mathematical Statistics	4	-	-	4	20	80	5	20
MAT6.5DCET409 (**Course** MAT6.5DCET304 is compulsory for this course)	General theory of Relativity and Cosmology (**Course** MAT6.5DCET304	4	-	-	4	20	80	5	20

Course code	Course title	L	T	P	Credit	Max. marks		Min. pass marks	
						Internal	External	Internal	External
	is compulsory for this course)								
MAT6.5DCET410	Programming in C++ (Theory)	4	-	-	4	20	80	5	20
MAT6.5DCEP411 (**Course** MAT6.5DCET410 is compulsory for this course)	Programming in C++ (Practical) (**Course** MAT6.5DCET410 is compulsory for this course)	-	-	4	4	20	80	5	20
Total Credits = 26 Total Marks = 600									

L: Lecture, T: Tutorial, P: Practical

DCC: Discipline centric compulsory course. AEC: Ability enhancement course.

Non-CGPA Courses are practice based courses having 2 Credits and assessed internally on the basis of continuous internal assessment (no examination will be conducted by the University). The college will send the Satisfactory (S) or Not Satisfactory (NS) credentials of the student to the University.

S/NS*=Satisfactory or Not satisfactory.

Scheme of examination:

Course code	Duration In hours	Maximum marks Internal/ External	Credits
MAT6.5AECT401			2
MAT6.5DCCT402	03	30/120	6
MAT6.5DCCT403	03	30/120	6

Any three of the following			
MAT6.5DCET404	03	20/80	4
MAT6.5DCET405	03	20/80	4
MAT6.5DCET406	03	20/80	4
MAT6.5DCET407	03	20/80	4
MAT6.5DCET408	03	20/80	4
MAT6.5DCET409 (**Course** MAT6.5DCET304 is compulsory for this course)	03	20/80	4
MAT6.5DCET410	03	20/80	4
MAT6.5DCEP411 (**Course** MAT6.5DCET410 is compulsory for this course)	03	20/80	4
Total Credits = 26 Total Marks = 600			

Note: Internal assessment is a continuous assessment and will be done on the basis of class room activities, test/assignment submission, seminar and viva-voice.

MAT6.5AECT401

VEDIC MATHEMATICS

Vedic sutras: Conceptual explanation and their applications.

Successful completion of the course is judged on the basis of seminar and viva-voice examination.

<u>CORE COMPULSORY</u>

MAT6.5DCCT402

Total Marks: 150(120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: The objective of this course is to familiarize the learner with the theory and application of linear integral equations. The course aims to develop students' ability to solve various types of integral equations, including Fredholm and Volterra equations, using different mathematical techniques.

Course Learning Outcomes: After doing this course student will be able to

- Understand the definition and classification of linear integral equations
- Convert initial and boundary value problems into integral equations.
- Compute eigenvalues and eigenfunctions for these equations.
- Solve homogeneous and general Fredholm integral equations of the second kind with separable kernels.
- Apply methods of successive substitutions and successive approximations to solve Fredholm and Volterra integral equations of the second kind.
- Understand the concept of the resolvent kernel, including conditions for uniform convergence and the uniqueness of series solutions.
- Understand integral equations with symmetric kernels.
- Understand fundamental properties of eigenvalues and eigenfunctions.
- Apply the Hilbert-Schmidt theorem to solve Fredholm integral equations of the second kind.
- Solve Volterra integral equations of the second kind with convolution-type kernels using Laplace transforms
- Solve Fredholm integral equation of second kind by Fredholm first theorem.
- Apply this knowledge of integral equations to solve complex mathematical problems arising in physics, engineering, and applied mathematics.

INTEGRAL EQUATION

Unit I

Linear integral equations: Definition and classification. Conversion of initial and boundary value problems to an integral equation. Eigen values and Eigen functions. Solution of homogeneous and general Fredholm integral equations of second kind with separable kernels.

Unit II

Solution of Fredholm and Volterra integral equations of second kind by methods of successive substitutions and successive approximations. Resolvent kernel and its results.

Unit III

Integral equations with symmetric kernels: Orthogonal system of functions. Fundamental properties of eigen values and eigen functions for symmetric kernels, Expansion of eigen functions and bilinear form, Hilbert-Schmidt theorem. Solution of Fredholm integral equations of second kind by using Hilbert-Schmidt theorem.

Unit IV

Solution of Volterra integral equations of second kind with convolution type kernels by Laplace transform. Fredholm theorems. Solution of Fredholm integral equation of second kind by using Fredholm first theorem.

Unit V

Solution of singular integral equations, Abel integral equation and its particular cases, weakly singular kernel, iteration of the singular equation, Fredholm operator, equivalence of the Fredholm integral equation and the iterated equation, Solution of Cauchy-type singular integral equation.

Books Recommended for References:

1. Lovitt W.V: Integral Equations, Dover Publications.
2. Kanwal R.P: Linear Integral Equations, Academic Press, New York.
3. Shanti Swaroop: Linear Integral Equations, Krishna Prakashan Mandir, Meerut.
4. Gokhroo et.al., : Linear Integral Equations, Navkar Prakashan, Ajmer.
5. Goyal and Goyal: Linear Integral Equations, JPH, Jaipur.

MAT6.5DCCT403

Total Marks: 150 (120 End of Semester Examination + 30 Internal Assessment)

Course Objectives: To familiarize students with the basic concepts of Functional Analysis involving normed linear spaces, Banach spaces Inner product spaces and Hilbert spaces, their properties the bounded linear operators and spectral theorem.

Course Learning Outcomes: After doing this course student will be able to

- Verify the requirements of a norm, completeness with respect to a norm, check boundedness of a linear operator and relate to continuity, convergence of operators by using a suitable norm,
- Understand Banach spaces, Inner product spaces and Hilbert spaces.
- Decompose a Hilbert space in terms of orthogonal complements, check totality of orthonormal sets.
- Represent a bounded linear functional in terms of inner product, classify operators into self-adjoint, unitary and normal operators.
- Extend a linear functional under suitable conditions, compute adjoint of operators,
- Check reflexivity of a space, ability to apply uniform boundedness theorem, open mapping theorem and closed graph theorem, check the convergence of operators
- Compute the spectrum of operators.

FUNCTIONAL ANALYSIS

Unit I

Normed Vector spaces, Banach Spaces and their examples.

Unit II

Continuous linear transformations, the natural imbedding, Hahn-Banach theorem and its application, Open mapping theorem, closed graph theorem, Uniform boundedness theorem.

Unit III

Inner product spaces. Hilbert space and their examples and properties, Cauchy Schwarz's inequality, Parallelogram Law, Orthogonal complements, Orthonormal sets Complete orthonormal sets, Bessel's inequality, Gram Schmidt orthogonalization process.

Unit IV

Conjugate space of Hilbert's space, Adjoint operator, self-adjoint and normal operators, projections and their properties.

Unit V

Linear operators and Matrices on a finite dimensional Hilbert space, spectrum of an operator on a finite dimensional Hilbert space, spectral theorem.

Books Recommended for Reference:

1. L.A. Lusternik and L.J. Sobolev: Elements of Functional Analysis, Hindustan Publishing Company (1974).
2. A.E. Taylor: Introduction to Functional Analysis (1958), John Wiley and Sons.
3. J. Dieudonne: Foundations of Modern Analysis (1969), Academic Press.
4. Kosaku Yosida: Functional Analysis (1974), Narosa Publishing House, New Delhi.
5. B. Choudhary and Sudarshan Nanda: Functional Analysis with Application (1989), Wiley Eastern Limited
6. Nahar, T.S: Functional Analysis, Navkar Prakashan.
7. Sharma, J.N.: Functional Analysis, Krishana Prakashan Mandir, Meerut.

CORE ELECTIVE (ANY THREE)

MAT6.5DCET404

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: This course will provide the students good familiarity with all initial notions of graph theory and related results. The students will learn the notion of trees and their usefulness in various problems. They will explore various algorithm. Planar graphs and associated Euler's theorem and coloring of graphs are also covered in the course.

Course Learning Outcomes: After doing this course student will be able to

- Frame problems using different types of graphs like trees, bipartite graphs and planar graphs.
- Understand and identify special graphs like Euler graphs and Hamiltonian graphs.
- Explain concepts of Eulerian circuits and Hamiltonicity in graphs.
- Understand various forms of connectedness in a graph and appreciate different graph-coloring problems and their solutions.
- Apply the concepts of graphs to model them in real life situations.

GRAPH THEORY

Unit I

Graph and related terminology, Complete and bipartite graph, Weighted graph. Basic properties of graph, Isomorphism of graphs.

Unit II

Path and circuits in a graph. Eulerian graphs, Hamiltonian cycles, Matrix representation of a graph.

Unit III

Distance in a graph, shortest path and Dijkstra's algorithm, Warshall algorithm.

Unit IV

Trees, spanning tree algorithm, Minimum spanning tree algorithm, Kruskal's algorithm, Prim algorithm.

Unit V

Planar graphs. Eulerian formula. Cut vertices and cut edges. Edge connectivity. Vertex colouring of a graph. Edge colouring of a graph. Four colours theorem. Five colour theorem.

Books Recommended for Reference:

1. Harary, Addison: Graph Theory, Wesley 1969

2. D. B. West: Introduction to Graph Theory, Prentice Hall 1996.

3. Jonathan Gross and Jay Yellen: Graph Theory and its Applications, CRC 1998.

4. Gokhroo et. al.: Advanced Discrete Mathematics, Navkar Prakashan, AJMER

5. N. Deo: Graph Theory with Application to Engineering Computer Science. Prentice hall of India.

6. D. S. Chauhan and R. Pandey, Elements of Discrete Mathematics, Jaipur Publishing House, Jaipur.

MAT6.5DCET405

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: The objective of the study of generalized Hypergeometric function is to develop a unified frame work for understanding and working with a wide range of special functions and their properties.

Course Learning Outcomes: After completion of this course a student learns how to generalize the mathematical results involving special functions such as H function, a generalization of several special functions and a Hypergeometric function.

GENERALIZED HYPERGEOMETRIC FUNCTION

Unit I

Generalized Hypergeometric Functions: Definition, Convergence conditions for pFq, Differential equation for pFq and its solutions, Contiguous relation, Euler's type integrals involving pFq.

Unit II

Watson's, Dixon's, Whipple's and Saalschutz theorems for the series 3F2 with unit argument, Thomae's theorem. Product formulas due to Ramanujan, Preece and Bailey Theorems. Contour integral representation for pFq.

Unit III

H-Function: Definition, Convergence conditions, Series representations, Special cases, Transformation formulas and Identities.

Unit IV

Derivatives of H- Function, Multiplication formulas and Expansion formulas for H- Function.

Unit V

Recurrence relations and Contiguous function relations for H- Function.

Books Recommended for Reference:

1. Rainville, E.D.: Special functions, The Macmillan Co., (1960)

2. Saran N., Sharma, S.D. et.al.: Special functions, Pragati Prakashan, Meerut.

3. Mathai, A.M., Saxena, R. K and Hans J. Haubold, H. J.: The H-Function Theory and Applications, Springer New York.

MAT6.5DCET406

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: The main objective of this course is to provide the learner thorough knowledge about the formulations and solution techniques of nonlinear and dynamic programming.

Course Learning Outcomes: After doing this course student will be able to

- Understand the theoretical concepts of nonlinear programming problems and demonstrate solution approaches.
- Identify different optimization problems and their characteristics in real-life to be formulated as nonlinear programming problems.
- Understand the concepts of Quadratic programming problems and describe their various applications. Then, demonstrate solution methods for these problems.
- Formulate and solve nonlinear programming problems in which the objective function and constraints are separable functions using concepts of separable programming.
- Solve different types of real-life problems using Dynamic programming.

NON- LINEAR PROGRAMMING AND DYNAMIC PROGRAMMING

UNIT I

Existence theorems, first order optimality conditions and second order optimality conditions for unconstrained optimization problems.

UNIT II

Convex functions, differentiable convex functions, optimization on convex sets, separation theorems, fritz john optimality conditions for constrained non-linear programming problems, constraint qualifications, karush-kuhn-tucker conditions in non-linear programming, second order conditions in nonlinear programming.

UNIT III

Lagrangian saddle points, duality in nonlinear programming, strong duality in convex programming, duality for linear and quadratic problems.

UNIT IV

Quadratic programming method due to Wolfe and Frank, convex simplex method, penalty function methods.Conditions for non-linear programming problem, Kuhn Tucker conditions for optimization for non-linear programming problem.

Unit V

Dynamic programming, Decision tree and Bellman's principle of optimality, concepts of dynamic programming, Minimum path problem model, Single additive constraint and multiplicatively separable return model, Single additive constraint and additively separable return model, Mathematical formulation of multistage model.

Books Recommended for Reference:

1. O. Güler: Foundations of Optimization, Springer 2010.

2. T.L. Saaty: Mathematical Methods of Operational Research.

3.Sasieni, Friedman and Yaspan: Operations Research.

4.Bellmen R.: Dynamic Programming.

5.Vajda: Mathematical Programming.

6. G Hadley: Nonlinear and Dynamic Programming, Addison-Wesley.

7. O.L Mangasarian: Non -Linear Programming: McGraw Hill.

8. Gokhroo et. al.: Advanced Operations Research, Navkar Prakashan, AJMER.

9. Sharma S.D.: Operations Research.

MAT6.5DCET407

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: The aim of this course is to provide the students thorough understanding of fundamental principles in fluid mechanics and thermodynamics, as well as their applications in elasticity and fluid dynamics.

Course Learning Outcomes: After doing this course student will be able to

- Classify continuous media, distinguish between body forces and surface forces, and derive the components of the stress tensor along with the equations of equilibrium, including principal stresses and stress invariants.
- Differentiate between Lagrangian and Eulerian descriptions of motion, analyze velocity, acceleration, and strain tensors, and derive the continuity equation in the context of fluid mechanics.
- Explain the geometrical meaning of linear strain tensor.
- Understand and apply the law of conservation of mass and the Eulerian continuity equation, as well as utilize the Reynolds transport theorem and momentum integral theorem in various engineering applications.
- Understand the kinetic equation of state and the first and second laws of thermodynamics.
- Apply the generalized Hooke's law for isotropic homogeneous solids.
- Solve problems related to linear elasticity.
- Apply compatibility equations (Beltrami-Michell equations), strain energy functions and the uniqueness theorem.
- Apply fundamental fluid dynamics principles, including the kinetic equation of state, equations of motion, vorticity-stream surfaces for inviscid flow, and Bernoulli's equations.
- Understand irrotational flow and velocity potential concepts and their applications in fluid dynamics.
- Use this knowledge of thermodynamics and fluid dynamics to solve practical engineering problems.

CONTINUUM MECHANICS

Unit I

Cartesian Tensors, Index notations and transformation, Laws of Cartesian tensors, Addition, Subtraction and multiplication of Cartesian tensor, Gradient of a scalar function, Divergence of a vector function and curl of a vector function using the Index notation, ε-δ identity, Stokes, Gauss and Green's theorems.

Unit II

The continuum approach classification of continuous media, Body forces and surface forces, Components of stress tensor, Force and moment equation of equilibrium, The stress quadric, Principal stresses and Principal axes, Stress invariants and the stress deviator tensor, Maximum shearing stress, Lagrangian and Eulerian description of deformation of flow, the comoving derivative, Velocity and acceleration, The continuity equation.

Unit III

Strain tensors, The linear rotation tensor and rotation vector, Analysis of rotation displacement, Geometrical meaning of the components of the linear strain tensor, Principal axes, theory for the linear strain tensor, properties of Linear strain tensors, The linear cubical dilatation, Compatibility equations for the linear strain components.

The rate of strain tensors and the vorticity tensor, The rate of rotation vector and the vorticity, Properties of the rate of strain tensor, Rate of cubical dilatation.

Unit IV

Law of conservation of mass and Eulerian Continuity equation, The momentum integral theorem and the equation of motion, Kinetic equation of state, The first and the second law of thermodynamics and the dissipation function.

Application: (Linear elasticity): Assumption and basic equations, Generalized Hooke's Law for an isotropic Homogeneous solid, Compatibility equations, Classification of types of problems in linear elasticity, The Principle of superposition.

Unit V

The strain energy function, The uniqueness theorem P.I. Relationship and the work kinetic energy equation, Irrotational flow and the velocity potential, Kinetic equation of state and the First Law of Thermodynamics. The equation of continuity, the equations of motion, Vorticity-Stream Surface for inviscid flow, Bernoulli's equations, Irrotational flow and the velocity potential, Similarity parameters and fluid flow.

Books Recommended for Reference:

1. D. Frederic and T.S. Chang: Continuum Mechanics, Ally and Bacon. Inc. Boston
2. Mase. G.E: Continuum Mechanics (Schaum series)
3. Sommerfield A: Mechanics Deformable bodies.
4. Morton E. Gurtin: An Introduction to Continuum Mechanics (Academic Press)
5. Sharma, K.D.: Continuum Mechanics, Navkar Prakashan, AJMER.

MAT6.5DCET408

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: Introduce the learners the concept of probability, Mathematical Expectation, Discrete and Continuous distributions and their applications. The students will learn Central limit theorem for distributions to calculate probability, Correlation and regression and their properties, index number, test of significance for large sample tests for proportion and mean, small sample test based on t, F and χ^2statistics.

Course Learning Outcomes: After doing this course student will be able to

- Determine the sample space and find probability, conditional probability, density function, distribution function.
- Understands mathematical expectation, Generating function, continuous probability distribution.
- Apply Chebyshev and Kolmogorov inequality.
- Understands various continuous probability distributions and their applications.
- Understands methods of least square and curve fitting and can use it in the problems.
- Calculate correlation and regression coefficient, Index numbers to interpret data

- Understand different types of sampling methods and their errors.
- Test hypotheses about population means and proportions using large and small sample theory.

MATHEMATICAL STATISTICS

Unit I

Sample spaces, Combination of events, Statistical independence, Conditional probability- Bayes theorem, Repeated trials, Random Variable, Distribution function, Probability function, Density function.

Unit II

Mathematical expectation, Generating function (mgf and pgf) continuous probability distribution characteristic function, Fourier's Inversion, Chebyshev and Kolmogorov inequality. Weak and Strong laws of large numbers, Normal, Hyper-geometric, Rectangular, Negative Binominal, Beta, Gamma and Cauchy's distribution.

Unit III

Methods of least square and curve fitting, correlation and regression coefficient. Index numbers, Introduction, Price-relatives, Quantity relatives, Value relatives. Link and Chain relatives, Aggregate methods, Fisher's Ideal Index, Change of the base period of the index numbers.

Unit IV

Elementary sampling theory, Distribution of means of samples from Binomial, Cauchy, Rectangular and normal distributions. Distribution of second order moments in samples from normal population, Exact distributions of χ^2, t, z and F.

Unit V

Statistics in samples from a normal population, Their simple properties and applications. Test of significance of difference between two means and two standard deviations for large samples with modification for small samples and taken from normal population.

Books Recommended for Reference:

1. Kapur and Saxena: Mathematical Theory of Statistics.

2. Weatherburn: A First Course in Mathematical Statistics.

3. M.G. Kendall: The Advanced Theory of Statistics.

4. Uspensky: Introduction of Mathematical Probability.

5. Gokhroo et. al: Advanced Mathematical Statistics, Navkar Prakashan.

MAT6.5DCET409

(**Course** MAT6.5DCET304 is compulsory for this course)

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: To provide the learners the thorough knowledge of the fundamental concepts and mathematical framework of general relativity. Students will be introduced to the key topics such as Mach's principle, the nature of singularities, relativistic orbits, tests of General Relativity, and cosmological models. Relativistic differential equation for the orbit of the planet, Birkhoff's theorem etc. are also covered in the course.

Course Learning Outcomes: After doing this course student will be able to

- Understand and apply Mach's principle and the Newtonian approximation of the equation of motion.
- Derive and analyze Einstein's field equations for matter and empty space, and understand their reduction to Poisson's equation.
- Explain the removal of the clock paradox in General Relativity.
- Analyze the Schwarzschild exterior metric and its isotropic form, including the identification and implications of singularities.
- Derive key relationship such as $GM=c^2m$ and calculate the mass of the sun in gravitational units.
- Formulate and solve the relativistic differential equations governing the orbits of planets.

- Describe and analyze the three crucial tests of General Relativity and understand their significance.
- Explore the analogues of Kepler's laws in the context of General Relativity,
- Understand the Schwarzschild interior metric and the corresponding boundary conditions.
- Understand the Lorentz invariance of Maxwell's equations in empty space and calculate the Lorentz force on a charged particle.
- Derive the energy-momentum tensor for electromagnetic fields and understand its role in Einstein's field equations with a cosmological term.
- Understand Einstein and de-Sitter models static cosmological models and their physical and geometrical properties.

GENERAL RELATIVITY AND COSMOLOGY

Unit I

Mach's principle, Newtonian approximation of equation of motion, Einstein's field equation for matter and empty space, Reduction of Einstein's field equation to Poisson's equation, Removal of clock paradox in General Relativity.

Unit II

Schwarzschild exterior metric, its isotropic form, Singularity and singularities in Schwarzschild exterior metric, Derivation of the formula $GM=c^2 m$, Mass of sun in gravitational unit.

Unit III

Relativistic differential equation for the orbit of the planet, Birkhoff's theorem, Three crucial tests in General Relativity and their detailed descriptions, Analogues of Kepler's laws in General Relativity, Trace of Einstein tensor.

Unit IV

Energy-momentum tensor and its expression for perfect fluid, Schwarzschild interior metric and boundary condition, Lorentz invariance of Maxwell's equations in empty space, Lorentz force on charged particle, Energy-momentum tensor for electro-magnetic field.

Unit -V

Electromagnetism in General Relativity, Derivation of Einstein's Maxwell's equations from Action Principal, Einstein's field equation with cosmological term, static cosmological models (Einstein & de-Sitter models) with physical and geometrical properties, difference between Einstein and de-sitter universe.

Books Recommended for Reference

1. Parkash: Relativistic Mechanics.

2. Goyal et al: Theory of Relativity, Pragati Prakashan Meerut.

3. Rajbali Theory of Relativity, Jaipur Publishing House, Jaipur.

MAT6.5DCET410

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: Make the learners aware of a high-level language C++. Students will learn editing and compiling C++ programs. They will explore the essential elements of C++ programming: variables, loops, expressions, functions, string, classes, error debugging and execution of code.

Course Learning Outcomes: After doing this course student will be able to

- Understand what C++ is and its use.
- Create and use variables with different data types.
- Use if statements and loops like for and while.
- Write functions and use arrays.
- Work with strings.
- Understands the significance of various types of classes.
- Identify errors and debug them.
- Write simple word problem into C++.
- Compile and run code.

PROGRAMMING IN C++ (Theory)

Unit I

Introduction to C++, basic structure of C++ programming, C++ basics I/O, Character set, Constant, Variables and Data Types, Scope of Variables and Type Conversion.

Unit II

Operators in C++: Arithmetic Operators, Assignment Operator, Relational Operators, Logical Operators, Size of Operators, Increment and Decrement Operators, Operator Precedence and associativity. Bitwise operators.

Unit III

Decision making statement, Looping and branching, while statement, do statement, for statement, go to statement.

Standard and User-Defined Function, Recursive function, Passing by Value and Reference, Pointers and functions, Reference and Functions.

Unit IV

String, string declaration and initialization, string manipulation, string input, passing string to function, string operations, Array of string.

basic object-oriented features, namespace.

Unit V

One, Two and Multidimensional Arrays, Passing Array to a function, Error identification and debugging.

MAT6.5DCEP411(Practical)

(**Course** MAT6.5DCET410 is compulsory for this course)

Total Marks: 100 (80 End of Semester Examination + 20 Internal Assessment)

Course Objectives: Make the learners aware of a high-level language C++ and hands-on experience on computers.

Course Learning Outcomes: After doing this course student will be able to

- Write, compile, run and debug a code in C++ for problems on sorting, matrix multiplication, numerical analysis, statistics etc.

PROGRAMMING IN C++ (Practical)

C++ Programming problems on:

- Sorting of numerical character. string data etc
- Solution of quadratic equations numerical analysis,
- Solution of equations, algebraic and transcendental, using other methods like bisection method, Newton Raphson Method etc.
- Mean, Standard deviation, Correlation coefficient etc.
- Fitting of curves, least square approximations.
- Arrays.
- Matrices and its applications.

Distribution of Marks:

Three Practical (20 Marks each) = 60 Marks

Practical Record= 10 Marks

Viva - Voce= 10Marks

Total Marks= 80 Marks

Note:

3. Each candidate is required to appear in the Practical examination to be conducted by internal and external examiner. External examiner will be appointed by the University through BOS and internal examiner will be appointed by the Head of the Department / Principal of the College.
4. Each candidate has to prepare his / her practical record.

Book Recommended for Reference:

1. E Balagurusamy: Object-Oriented Programming with C++, McGraw Hill.

2. D Ravichandran: Programming with C++ McGraw-Hill.
3. Jana: C++ and Object-Oriented Programming, PHI Learning.
4. Kamthane A. N.: ANSI and Turbo C++ by Pearson Education.
5. Venugopal: Mastering C++, McGraw-Hill Education (India).