Draft Syllabus
for
Four-Year (Eight-Semester)

Undergraduate Program
in
Mathematics

Interdisciplinary/Disciplinary Minor Course

(as per NEP 2020)

(Effective from Academic Session 2024-2025)

University of Gour Banga
Malda-732103
West Bengal

Name of Interdisciplinary/Disciplinary Minor Papers
Semester I to VIII

(Each carries 4 credits)

Semester	Course Code	Course Name
I	MTM-IDC/DC-MN-101	Classical Algebra and Analytical Geometry
II	MTM-IDC/DC-MN-201	Calculus with Applications
III	MTM-IDC/DC-MN-301	Linear Algebra and Vector Calculus
IV	MTM-IDC/DC-MN-401	Higher Calculus with Applications
V	MTM-IDC/DC-MN-501	Differential Equations and Integral Transforms
VI	MTM-IDC/DC-MN-601	Algebra and Graphs
VII	MTM-IDC/DC-MN-701	Numerical Methods and Probability Theory
VIII	MTM-IDC/DC-MN-801	Optimization Techniques

NOTE: Each interdisciplinary/disciplinary minor paper is of 4 credits (75 marks, out of which 25 marks is allotted for Continuous Assessment (**CA**) and 50 marks is allotted for Semester-End (**SE**) examination).

SEMESTER I

MTM-IDC/DC-MN-101
Classical Algebra and Analytical Geometry
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The primary objective of this course is to introduce the basic tools of complex numbers, inequalities, theory of equations, and analytical geometry of two and three dimensions. This course gives students a good mathematical skills in the beginning.

Learning Outcomes:

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

1. Understand the polar representation of complex numbers and employ De Moivre's theorem in a number of applications to solve problems, and solve various problems based on inequalities.
2. Familiar with the theory of equations which includes relation between roots and coefficients, transformation of equation, Descartes rule of signs, solution of cubic equation (Cardan's method).
3. Understand the transformations of coordinate axes in 2D, namely, translations, rotations and their compositions, and familiar with pair of straight lines in 2D and related properties.
4. Acquire knowledge on 3D coordinates system and have a detailed clear-cut idea of planes, straight lines, spheres, cones and cylinders in 3D.

Course Contents

Module 1: Complex Numbers and Inequalities

Complex Number: De Moivre's theorem and its applications. Exponential, Sine, Cosine and Logarithm function, definition of $a^z (a \neq 0)$, Inverse circular and hyperbolic functions.

Inequality: Simple applications of inequality involving $AM \geq GM \geq HM$, m-th power inequality, Cauchy-Schwarz inequality.

Module 2: Theory of Equations

Polynomials with real coefficients. Fundamental theorem of Algebra (Statement only), Nature of roots of an equation (surd or complex roots occur in pairs), Existence of real roots, Descartes's rule of signs and application of intermediate value theorem, Relation between roots and coefficients, symmetric function of roots, Cardan's method of a cubic equation.

Module 3: Analytical Geometry of 2D

Transformation of Rectangular axes. Translation, Rotation and its combinations, Pair of straight lines, Condition that the general equation in second degree may represent two straight lines, Point of intersection of two intersecting lines, Angles between two straight lines, Equation of bisectors, Equation of two lines joining the origin to the points in which a line meet a conic, Tangents and Normals, Poles and Polars.

Module 4: Analytical Geometry of 3D

Three dimensional coordinate system, Straight line, Direction Cosine, Problems on Straight Lines, Equation of plane and elementary properties, Sphere and its tangent plane, Right circular cone and cylinder (Simple problems).

References

[1] R. Cooke, Classical Algebra: Its Nature, Origins, and Uses, Wiley, United Kingdom, 2008.

[2] S. Bernard and J.M. Child, Higher Algebra, Macmillan and Co., 1952.

[3] T. Andreescu and D. Andrica, Complex Numbers from A to... Z, Birkhäuser, 2006.

[4] W.S. Burnside and A.W. Panton, The Theory of equations, Dublin University Press, 1954.

[5] A. Baker, Analytical Geometry for Beginners, FB&C Limited, United States, 2015.

[6] S. L. Loney, The Elements of Coordinate Geometry, Macmillan and Co., 1895.

[7] R.J.T. Bell, An Elementary Treatise on Coordinate Geometry of Three Dimensions, Macmillan and Co., 1910.

[8] G.B. Thomas and R.L. Finney, Calculus and Analytical Geometry, 14th Edition, Pearson Education, Delhi, 2018.

SEMESTER II

MTM-IDC/DC-MN-201
Calculus with Applications
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The objective of this course is to build up problems based mathematical treatment in single-variable differential and integral calculus involving the fundamental tools such as limits, continuity, differentiability and integrability. This course is essential to solve optimization problems appearing in social sciences, physical sciences, life sciences and a host of other disciplines.

Learning Outcomes:

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

1. Understand the convergence of sequence and series, and the concepts of limit, continuity and differentiability on $\mathbb{R}$, calculate the limit, examine the continuity and the derivative of a function at a point.
2. Familiar with the consequences of various mean value theorems for differentiable functions, application of differential calculus in finding extrema, concavity, envelopes, asymptotes, curve sketching, etc., and able to find higher order derivatives and apply the Leibnitz rule to solve problems related to such derivatives
3. Solve problems using the different methods of integration, use techniques of Reduction formulae, understand several properties of definite integrals, and familiar with improper integrals, and use Beta and Gamma functions to solve various problems.
4. Apply the integral calculus to find arc length of a curve, arc length of parametric curves, area between curves, volumes using cross-sections and cylindrical shells, areas of surfaces of revolution, work and fluid forces, moments and centres of mass.

Course Contents

Module 1: Differential Calculus

Real Number System, Algebraic and Order Properties of Real Numbers, Least Upper Bound Property of Real Numbers, Archimedean Property of Real Numbers.

Sequence of real numbers: Definition of bounds of a sequence and monotone sequence, Limit of a sequence, convergent, divergent and oscillatory sequences.

Convergence of infinite series. Series of positive terms: Comparison tests, Tests of convergence: D Alembert's ratio test, Cauchy's nth root test, Raabe's tests, Alternating series, Statement of Leibnitz test and its applications.

Concept of limits, continuity and differentiability. Indeterminate Forms and L'Hôpital's Rule, Higher Order Derivatives, Leibnitz Rule of Successive Differentiation and its Applications.

Module 2: Applications of Derivatives

The Mean Value Theorem, Monotonic Functions, Extreme Values of Functions, The First Derivative Test for Relative Extrema, Second Derivative Test for Relative Extrema, Concavity and inflection points, radius of curvature, Envelopes, Asymptotes.

Module 3: Integral Calculus

Indefinite Integrals, Basic Integration Formulae, Substitution Method, Integration by Parts, Integration of Rational Functions by Partial Fractions, Reduction Formulae, Sigma Notation and Limits of Finite Sums, Concept of Riemann Sum and Definite Integrals, Concepts of Antiderivatives, Fundamental Theorem of Integral Calculus, Substitution in Definite Integrals, Concept of Improper Integration, Beta and Gamma Functions and Related Problems.

Module 4: Applications of Integrals

Areas Between Plane Curves, Parametric Equations, Parametrizations of Plane Curves, Volumes Using Cross-Sections, Volumes Using Cylindrical Shells, Concept of Arc Length, Computation of Arc Lengths of Parametrized Plane Curves, Areas of Surfaces of Revolution, Work and Fluid Forces, Moments and Centres of Mass.

References

[1] T.M. Apostol, Calculus, Volume I: One-variable Calculus, with an Introduction to Linear Algebra, 2nd Edition, Wiley India Pvt. Limited, 2007.

[2] G.B. Thomas and R.L. Finney, Calculus and Analytical Geometry, 14th Edition, Pearson Education, Delhi, 2018.

[3] H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, Wiley India Pvt. Ltd., 2016.

[4] G. Osborne, Differential and Integral Calculus with Examples and Applications, Revised Edition, D.C. Health & Co. Publishers, Boston, U.S.A, 1906.

[5] M.J. Strauss, G.L. Bradley and K.J. Smith, Calculus, 3rd Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, Indian Reprint, 2011.

[6] J. Stewart, Calculus: Concepts and Contexts, Alternate Edition, Brooks/Cole Cengage Learning, Austria, 2009.

[7] R.A. Silverman, Essential Calculus with Applications, Dover Publications, USA, 2013.

[8] R. Larson, R.P. Hostetler and B. Edwards, Calculus, Cengage Learning, UK, 2006.

SEMESTER III

MTM-IDC/DC-MN-301
Linear Algebra and Vector Calculus
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The objective of this course to teach the students how linear algebra and vector calculus are ubiquitous in Mathematics and therefore strong foundation has to be laid in studying the algebraic concepts intertwining geometric ideas.

Learning Outcomes:

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

1. Understand different types of Matrices and their types, find rank and determinants of matrices, recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix using rank.
2. Learn fundamental concepts of vector spaces, inner product spaces and linear transformations, compute eigenvalues and corresponding eigenvectors for square matrices, with some applications.
3. Use vector function to represent space curves and surfaces, find arc Length, curvature, torsion and various other quantities, and know physically and geometrically important concepts related to gradient, divergence and curl of vector field.
4. Evaluate integrals of vector valued function over curves, surfaces and domains in two and three-dimensional space, and realize importance of Green, Gauss and Stokes' theorems in other branches of Mathematics.

Course Contents

Module 1: Matrices, Determinants, Linear Systems

Matrices, Matrix Multiplication, Transpose of a Matrix, Special Matrices: Symmetric, Skew-Symmetric, Hermitian and Orthogonal Matrices, Elementary Row Operations, Reduced Row Echelon Form, Rank of a Matrix, Linear Systems of Equations, Homogeneous Linear Systems, Nonhomogeneous Linear Systems, Solutions of Linear Systems: Existence and Uniqueness, Determinants, Cramer's Rule, Inverse of a Matrix.

Module 2: Vector Spaces, Matrix Eigenvalue Problems

The concept of Vector Spaces, Inner Product Spaces, Linear Transformations. Characteristic Equation, Cayley-Hamilton Theorem, The Matrix Eigenvalue Problem (Determining Eigenvalues and Eigenvectors), Some Applications of Eigenvalue Problems, Quadratic Forms.

Module 3: Vector Differential Calculus

Vectors in $\mathbb{R}^2$ and $\mathbb{R}^3$, Inner Product (Dot Product), Vector Product (Cross Product), Scalar and Vector triple Product, Vector Functions of One Variable, Derivatives of Vector Functions, Curves, Velocity, Arc Length, Curvature, Scalar and Vector Fields, Gradient of a Scalar Field, Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field, Physical Interpretations of Divergence and Curl.

Module 4: Vector Integral Calculus

Line Integrals, Green's theorem (statement only) and its applications, Parametric representation of surface, Surface integral, Volume integral, Statement of Stoke's theorem and Gauss divergence theorem and its applications.

References

[1] G.H. Golub and C.F.Van Loan, Matrix Computations, Third Edition, Johns Hopkins Series in the Mathematical Sciences, 1996.

[2] G. Strang, Introduction to Linear Algebra, Sixth Edition, Wellesley-Cambridge Press, 2023.

[3] S.H. Friedberg, A.J. Insel and L.E. Spence, Linear Algebra, 4th Edition, Prentice-Hall of India, New Delhi, 2004.

[4] K. Hoffman and R. Kunze, Linear Algebra, 2nd Edition, Prentice-Hall of India, New Delhi, 2000.

[5] S. Kumaresan, Linear Algebra-A Geometric Approach, Prentice-Hall of India, New Delhi, 2001.

[6] E. Kreyszig, Advanced Engineering Mathematics, 6th Edition, John Wiley and Sons, New York, 1988.

[7] T.M. Apostol, Calculus, Volume II: Multi-Variable Calculus and Linear Algebra, with Applications to Differential Equations and Probability, 2nd Edition, Wiley India Pvt. Limited, 2007.

[8] P.C. Matthews, Vector Calculus, Springer, London, 2012.

SEMESTER IV

MTM-IDC/DC-MN-401
Higher Calculus with Applications
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The aim of this course is to provide students with fundamental concepts and techniques of Fourier series and multivariable calculus and to develop student understanding and skills for its applications to other areas.

Learning Outcomes:

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

1. Understand the properties of Fourier series of periodic functions and solve the related problems.
2. Understand vector-valued functions and apply them to describe space curves with TNB-frame.
3. Extend the basic ideas of single-variable differential calculus to functions of several variables, compute partial derivatives, directional derivatives, gradient vectors, extreme values.
4. Compute double integral of a function of two variables over a region in the plane as the limit of approximating Riemann sums, and compute triple integrals for a function of three variables over a region in space.

Course Contents

Module 1: Fourier Series and Differentiation Under Integral Sign

Fourier Series: Even and Odd functions, Half range expansions, convergence of Fourier series (Dirichlet's condition), Fourier Integral, Differentiation under Integral Sign.

Module 2: Vector-Valued Functions and Space Curves

Vector-Valued Functions, Curves in Space and Their Tangents, Integrals of Vector-Valued Functions, Arc Length in Space Curves and the Unit Tangent Vector T, Curvature and Normal Vectors of a Space Curve, Binormal Vectors and Torsion of a Space Curve, TNB-frame along a Space Curve.

Module 3: Multivariable Functions and Partial Derivatives

Functions of Several Variables, Limits and Continuity in Higher Dimensions, Partial Derivatives, The Chain Rule, Directional Derivatives and Gradient Vectors, Tangent Planes and Differentials, Extreme Values and Saddle Points, Lagrange Multipliers, Taylor's Formula for Two Variables, Partial Derivatives with Constrained Variables.

Module 4: Multiple Integrals

Double and Iterated Integrals over Rectangles, Double Integrals over General Regions, Area by Double Integration, Double Integrals in Polar Form, Triple Integrals in Rectangular Coordinates, Moments and Centres of Mass, Triple Integrals in Cylindrical and Spherical Coordinates, Substitutions in Multiple Integrals.

References

[1] T.M. Apostol, Calculus, Volume II: Multi-Variable Calculus and Linear Algebra, with Applications to Differential Equations and Probability, 2nd Edition, Wiley India Pvt. Limited, 2007.

[2] G.B. Thomas and R.L. Finney, Calculus, 14th Edition, Pearson Education, Delhi, 2018.

[3] H. Anton, I. Bivens and S. Davis, Calculus, 10th Edition, John Wiley & Sons Singapore Pvt. Ltd., Indian Reprint by Wiley India Pvt. Ltd., Delhi, 2016.

[4] G. Osborne, Differential and Integral Calculus with Examples and Applications, Revised Edition, D.C. Health & Co. Publishers, Boston, U.S.A, 1906.

[5] M.J. Strauss, G.L. Bradley and K.J. Smith, Calculus, 3rd Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, Indian Reprint, 2011.

[6] J. Stewart, Calculus: Concepts and Contexts, Alternate Edition, Brooks/Cole Cengage Learning, Austria, 2009.

[7] R.A. Silverman, Essential Calculus with Applications, Dover Publications, USA, 2013.

[8] R. Larson, R.P. Hostetler and B. Edwards, Calculus, Cengage Learning, UK, 2006.

SEMESTER V

MTM-IDC/DC-MN-501
Differential Equations and Integral Transforms
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The main objective of this course is to increase the efficiency of the students with ordinary and partial differential equations and Laplace and Fourier transforms to solve various problems in science and engineering.

Learning Outcomes:

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

1. Understand broad classification of differential equations and learn the different standard modules to identify the types of differential equations.
2. Apply suitable procedure to find the solution of first order ordinary differential equations with constant and variable coefficients, and understand mathematical modelling using differential equations to solve problems appeared in the field of Applied Physics.
3. Acquire knowledge on formation of partial differential equations, and learn how to use a variety of techniques to find solutions to first order partial differential equations.
4. Familiar with the Laplace and Fourier Transforms and their properties, such as linearity, time shifting, time scaling, convolution, and apply the knowledge of Laplace and Fourier transform to solve the differential equations.

Course Contents

Module 1: First-Order ODEs

Basic Concepts, Modelling, Geometric Meaning of $y' = f(x, y)$, Exact ODEs, Integrating Factors, Linear ODEs, Bernoulli Equation, Homogeneous ODEs, Clairaut's form, Singular Solution, Existence and Uniqueness Theorem for Initial Value Problems (Application Only), Orthogonal Trajectories.

Module 2: Second-Order ODEs

Homogeneous Linear ODEs of Second Order, Homogeneous Linear ODEs with Constant Coefficients, Differential Operators, Euler-Cauchy Equations, Existence and Uniqueness of Solutions, Wronskian, Nonhomogeneous ODEs, Solution by Variation of Parameters.

Module 3: Partial Differential Equations

Formation of partial differential equations, Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Solution partial differential equations of first order, Lagrange's method, Charpit's method.

Module 4: Laplace and Fourier Transforms

Laplace Transform: Linearity, Applications of First Shifting Theorem (s-Shifting), Transforms of Derivatives and Integrals, Unit Step Function (Heaviside Function), Applications of Second Shifting Theorem (t-Shifting), Short Impulses, Dirac's Delta Function, Partial Fractions, Convolution, Differentiation and Integration of Transforms, Inverse Laplace Transform. Applications of Laplace Transforms in Solving ODEs with Constant and Variable Coefficients.
Fourier Transforms: Fourier Sine and Cosine Transforms, Forced Oscillations, Inverse Fourier Transform, Applications of Fourier Transforms in Solving ODEs with Constant and Variable Coefficients.

References

[1] J. Hale, Ordinary Differential Equations, Dover Publications, 2009.

[2] W.H. Boyce and R.C. Diprima, Elementary Differential Equations and Boundary Value Problems (6th Edition), Wiley, New York, 1996.

[3] R.K. Nagle and E.B. Saff, Fundamentals of Differential Equations, 3rd Edition, Addison Wesley, Reading, MA, 1993.

[4] C.H. Edwards and D.E. Penney, Elementary Differential Equations with Applications, 3rd Edition, Prentice-Hall, Englewood Cliffs, NJ, 1996.

[5] V. Henner, T. Belozerova and M. Khenner, Ordinary and Partial Differential Equations, Taylor & Francis, United Kingdom, 2013.

[6] P. Blanchard, R.L. Devaney and G.R. Hall, Differential Equations (Preliminary Edition), PWS Publishing, Boston, 1996.

[7] M. Tenenbaum and H. Pollard, Ordinary Differential Equations: An Elementary Textbook for Students of Mathematics, Engineering and the Sciences, Dover Books on Mathematics, Dover Publications, Inc., New York, 1985.

[8] W.A. Strauss, Partial Differential Equations: An Introduction, Wiley, United Kingdom, 2008.

[9] J.L. Schiff, The Laplace Transform: Theory and Applications (Undergraduate Texts in Mathematics), Springer, New York, 2001.

SEMESTER VI

MTM-IDC/DC-MN-601
Algebra and Graphs
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The main objective of this course to introduce groups, rings, fields, graphs and Boolean algebra .

Learning Outcomes:

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

1. Familiar with concepts of groups, subgroups, cyclic groups, abelian groups, symmetric groups, and their applications.
2. Learn notions of rings and fields, and their applications.
3. Familiar with the major viewpoints and goals of graph theory: classification, extremality, optimization and sharpness, algorithms, and duality. Students will be able to apply their knowledge of graph theory to problems in other areas, possibly demonstrated by a class project.
4. Learn the basic principles of Boolean algebra and its underlying features, use truth tables and laws of identity, distributive, commutative, and domination, compute sum of products and product of sum expansions, convert Boolean expressions to logic gates and switching circuits.

Course Contents

Module 1: Groups

Set, relation, mapping, definition and elementary problems. Equivalence relation and equivalence classes. Binary operation.

Definition and examples of Groups: additive groups of integer, rational, real and complex numbers, multiplicative group of nonzero rational, real and complex numbers, congruence modulo group (Z_n and U_n), group of roots of unity, general linear group of order n, symmetric group (give stress to S_3). Elementary properties of Group, order of a group and order of an element in a group, their interrelation.

Definition and examples of subgroup, necessary and sufficient condition and its applications. Cyclic group and its elementary properties.

Module 2: Rings and Fields

Definitions and examples of Ring. Subring and Ideals, unit elements, zero divisor, integral domains.

Definition and example of fields and their elementary properties. Proof of every finite integral domain is a field. Examples of finite field, characteristic of a field.

Module 3: Graphs

Definition of undirected graphs, Use of graphs to solve different puzzles and problems, representing circuital network as a graph. Walks, Trails, Paths, Circuits and cycles, Eulerian circuits, Eulerian graphs, Examples of Eulerian graphs, Hamiltonian cycles and Hamiltonian graphs, Definition of Trees and their elementary properties.

Module 4: Boolean Algebras and Switching Circuits

Axioms of Boolean Algebra, De Morgan's law, Simplification of Boolean Expressions, Disjunctive Normal Form and Conjunctive Normal Form, Logic Gates, Switching Circuits and Applications of Switching Circuits.

References

[1] J.B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson, 2002.

[2] M.K. Sen, S. Ghosh, P. Mukhopadhyay and S. Maiti, Topics in Abstract Algebra, Uni- versity Press, 2019.

[3] K.A. Ross, Elementary Analysis: The Theory of Calculus, Springer, 2nd Edition, 2013.

[4] G.B. Thomas and R.L. Finney, Calculus and Analytical Geometry, 9th Edition, Pearson Education, Delhi, 2005.

[5] J.H. van Lint and R.M. Wilson, A Course in Combinatorics, Cambridge University Press, United Kingdom, 2001.

[6] V. Krishnamurthy, Combinatorics: Theory and Applications, Affiliated East-West Press, 1985.

[7] K. Erciyes, Discrete Mathematics and Graph Theory: A Concise Study Companion and Guide, Springer International Publishing, Germany, 2021.

[8] C.L. Liu and D.P. Mahopatra, Elements of Discrete Mathematics: A Computer Oriented Approach, 4th Edition, Tata McGraw Hill, 2017.

[9] K.H. Rosen, Discrete Mathematics and Its Application with Combinatorics and Graph Theory, McGraw-Hill Education, Pennsylvania, USA, 2011.

[10] M.O. Albertson and J.P. Hutchinson, Discrete Mathematics with Algorithms, John Wiley and Sons, USA, 1988.

SEMESTER VII

MTM-IDC/DC-MN-701
Numerical Methods and Probability Theory
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The main objectives of this course is to introduce numerical methods as techniques used to approximate mathematical procedures and probability theory that deals with probability in a rigorous mathematical manner.

Learning Outcomes:

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

1. Learn about the importance of error analysis and how it propagates, and learn how to solve interpolation problems, algebraic and transcendental equations.
2. Solve problems on numerical integration, and apply numerical methods to solve initial value problems and system of linear equations.
3. Understand the basic concepts of probability and learn how to apply probability theory to solve real-world problems.
4. Familiar with random variables and their characteristics, including expectation, variance, and covariance, and learn about discrete and continuous probability distributions and how to solve problems related to them.

Course Contents

Module 1: Error, Interpolations and Location of Roots

Approximate numbers, Significant figures, Rounding off numbers. Error: Absolute, Relative and percentage. Operators: Δ, ∇ and E (Definitions and relations between them).

Polynomial approximations, the problem of interpolation. Difference Tables, Newton's forward and backward interpolation formula, remainder term. Lagrange's Interpolation Formula. Numerical problems on Interpolation with both equally and unequally spaced arguments. Numerical differentiation.

To find a real root of an algebraic or transcendental equation. Location of root (tabular method), Bisection method, Iteration method, Regula Falsi method, Newton-Raphson method with geometrical significance, Numerical Problems. (Note: Emphasis should be given on problems).

Module 2: Numerical Integration, Initial Value Problems and System of Linear Equations

Numerical Integration: Trapezoidal and Simpson's one-third formula (statement only). Problems on Numerical integration.

Solving initial value problems using numerical methods. Euler's method, Runge-Kutta method of order 2 and order 4.

Numerical solution of system of linear equations: Gauss elimination , Gauss-Seidel methods.

Module 3: Probability Theory I

Elements of probability theory: Random experiment, outcome, sample space, event. Classical definition of probability and its limitations. Simple problems using classical definition. Axiomatic definition of probability and elementary properties. Conditional probability and Independence. Baye's theorem and its proof. Miscellaneous exercises on probability

Module 4: Probability Theory II

Random variable: Discrete and continuous. Probability distribution functions. Discrete distributions, probability mass function. Continuous distribution, probability density function. Cumulative distribution and its properties. Joint distribution function of two random variables.

Expectation and variance, elementary properties. Moment about the origin, moment about the mean, moment generating functions. Covariance and correlation coefficient.

Special discrete distribution function: Binomial and Poisson distribution, their mean and variance, simple problems. Special continuous distribution function: Uniform, normal, exponential distributions and their properties.

References

[1] K.E. Atkinson, An Introduction to Numerical Analysis, John Wiley and Sons, 1978.

[2] B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

[3] M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International, India, 2007.

[4] C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008.

[5] J.H. Mathews and K.D. Fink, Numerical Methods using Matlab, 4th Edition, PHI Learning Private Limited, 2012.

[6] A. Renyi, Probability Theory, Dover Publications, United States, 2007.

[7] E.T. Jaynes, Probability Theory: The Logic of Science, Cambridge University Press, United Kingdom, 2003.

[8] A. Klenke, Probability Theory: A Comprehensive Course, Springer London, 2008.

SEMESTER VIII

MTM-IDC/DC-MN-801
Optimization Techniques
Credit: 4
Full Marks: 75 (CA: 25, SE: 50)

Learning Objectives:

The primary objective of this course is to impart optimization techniques and to make the students become familiar with the basic principles of linear programming problem and enrich knowledge to apply the techniques of linear programming problem to solve real world problems.

Learning Outcomes:

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

1. Understand the formulation of linear programming problems and some basic principles, use graphical method to solve linear programming problems.
2. Familiar with simplex method, two phase method, big-M method.
3. Learn about the formulation of transportation problems and various techniques to solve them.
4. Understand the mathematical formulation of assignment problems and their solutions.

Course Contents

Module 1: Preliminaries of LPP

Motivation of Linear Programming problem (LPP), Statement of LPP, Formulation of LPP, Slack and Surplus variables, Objective Function of an LPP, Fundamental Theorem of LPP, LPP in matrix form. Graphical method of solving LPP. Convex set, Hyperplane, Extreme points, Extreme point Theorem for LPP, convex Polyhedron, Basic solutions and Basic Feasible Solutions (BFS). Degenerate and Non-degenerate BFS.

Module 2: Simplex Method

Simplex Method: Introduction, The computational procedure, The Simplex Algorithm, Use of Artificial variables, Two Phase method, Big-M method.

Module 3: Transportation Problem

Transportation problem: Definition, Formulation and solution of transportation problem, Initial Basic Feasible solution, Test for optimality, degeneracy in transportation problem, Modified Distribution Method (MODI).

Module 4: Assignment Problem

Assignment problem: Introduction, Mathematical formulation of the problem, solution methods of Assignment problems, Special cases in Assignment problems: Maximization case only.

References

[1] M.S. Bazaraa, J.J. Jarvis and H.D. Sherali, Linear Programming and Network Flows, 2nd Edition, John Wiley and Sons, India, 2004.

[2] F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Edition, Tata McGraw Hill, Singapore, 2009.

[3] H.A. Taha, Operations Research, An Introduction, 8th Edition, Prentice Hall India, 2006.

[4] G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

[5] P.R. Thie and G.E. Keough, An Introduction to Linear Programming and Game Theory, Wiley, Germany, 2011.

[6] S.I. Gass, An Illustrated Guide to Linear Programming, Dover Publications, 2013.

[7] E.D. Nering and A.W. Tucker, Linear Programs and Related Problems, Elsevier Science, United Kingdom, 1993.