SCHOOL OF SCIENCE
M. Sc. In Applied Mathematics
(Under UGC – CBCS)

Credit Definition

Type	Duration (inHour)	Credit
Lecture (L)	1	1
Tutorial (T)	1	1
Practical (P)	2	1

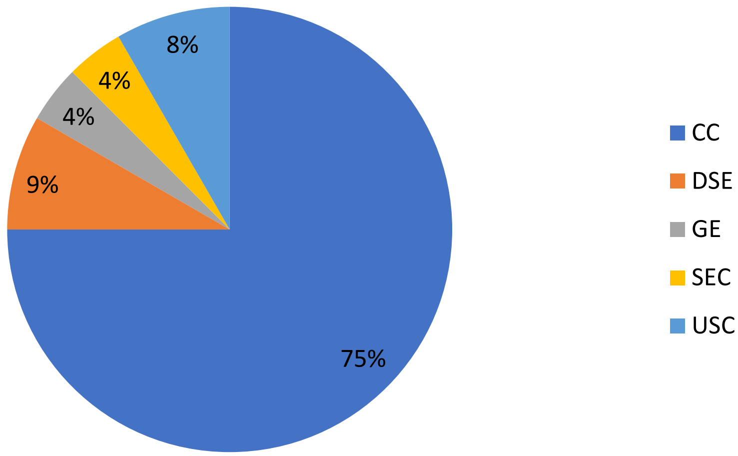
Total Credit

Year	Semester	Hr./Week	Credit
1st	1st	31	31
	2nd	31	27
2nd	3rd	25	23
	4th	27	15
Total			96

Category Codification with Credit Break up

Definition of Category	Code	No	Credit
Core Courses	CC	1	72
Discipline Specific Elective	DSE	2	8
General Elective	GE	3	4
Skill Enhancement Courses	SEC	4	4
University specified course	USC	5	8
Total			**96**

Category wise Credit Distribution



Subject Codification

Place value	1	2	3	4	5	6	7	8	9	10
Code	Course Category	Department Code		Program Code			Semester (for semester scheme)/Year(for annual scheme)	Subject Type (Theory/Practical/Sessional/Project/Internship)	Subject Serial Number	

<u>SEMESTER: I</u>

Mandatory Induction Program – Duration 3 weeks

- Physical Activity
- CreativeArts
- Universal HumanValues
- Literary
- ProficiencyModules

Sl No	Course Title	Code	Credit	Type		
				L	T	P
1	Abstract Algebra and Partial differential equation	1210021101	4	3	1	0
2	Real Analysis and Generalized functions	1210021102	4	3	1	0
3	Complex Analysis and ordinary differential equation	1210021103	4	3	1	0
4	Introduction to Continuum Mechanics	1210021104	4	3	1	0
5	Discrete Mathematics, Graph theory and Non-linear dynamics	1210021105	4	3	1	0
6	Linear models	2210021101	4	3	1	0
8	Foreign Language – I	6210021101	2	2	0	0
9	Mentor Seminar I	5210021601	1	1	0	0
Total Credit (CC: 20, DSE: 4, SEC: 1, USC: 2)			27	27 (hrs./Week)		

SEMESTER: II

Sl No	Course Title	Code	Credit	Type		
				L	T	P
1	Numerical Analysis	1210022301	6	3	1	4
2	Integral transforms and integral equations	1210022102	4	3	1	0
3	Python Programming	1210022303	6	3	1	4
4	Elastic deformation	1210022104	4	3	1	0
5	Management information system	1210022105	3	3	0	0
6	Foreign Language II	6210022102	2	2	0	0
7	Mentor Seminar II	5210022602	1	1	0	0
Total Credit (CC: 20, DSE: 4, USC: 2, SEC:1)			26	30 (hrs./Week)		

SEMESTER: III

Sl No	Course Title	Code	Credit	Type		
				L	T	P
1	Topology, functional analysis and operator theory	1210023101	4	3	1	0
2	Artificial Intelligence	1210023102	4	3	1	0
3	Optimization and operations research	1210023103	4	3	1	0
4	Machine Learning	1210023304	4	3	1	0
5	Financial Mathematics and Biomathematics	1210023105	4	3	1	0
6	Foreign Language III	6210023103	2	2	0	0
7	Mentor Seminar III	5210023603	1	1	0	0
Total Credit (CC: 20, USC: 2, SEC:1)			23	23 (hrs./Week)		

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SEMESTER: IV

Sl No	Course Title	Code	Credit	Type		
				L	T	P
1	Master Project / Dissertation	1210024501	12	0	0	24
2	Foreign Language IV	6210024104	2	2	0	0
3	Mentor Seminar IV	5210024604	1	1	0	0
Total Credit (CC: 12, USC: 2, SEC:1)			15	27 (hrs./Week)		

Programme Outcomes (PO):
By the end of the program the students will be able to:

PO1: Ability to acquire in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of mathematics. This also leads to study of related areas like computer science and physical science. Thus, this Program helps learners in building a solid foundation for higher studies in mathematics.

PO2: The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modelling and solving real life problems.

PO3: To recognize patterns and to distinguish between essential and irrelevant aspects of problems.

PO4: Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.

PO5: Ability to share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

PO6: Ability to communicate mathematics effectively by written, computational and graphic means.

PO7: Create mathematical ideas from basic axioms.

PO8: Ability to apply multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

PO9: Able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians

PO10: This Program will also help students to enhance their employability for jobs in banking, insurance and investment sectors, data analyst and in various other public and private enterprises.

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Course CC1: ABSTRACT ALGEBRA AND PARTIAL DIFFERENTIAL EQUATION
Credit 4: (3L-1T-0P)

Unit 1: Abstract Algebra:
Review of general concepts in classical algebraic systems, Dihedral groups, Caley's theorem. Generator of an arbitrary group, Commutator subgroup, Group automorphisms; Conjugate classes, Centralizer or normalizer; The Class equation, Group Action, Cauchy's theorem, Sylow's p-subgroups, Sylow's theorems and applications; Direct product of groups; Structure theorem for finitely generated Abelian groups.
Group representations, Reducible and irreducible representations, Unitary representation, Schur's lemma, Orthogonality theorem, Characters of a representation, Continuous groups, Lie groups and their algebras; Generators of a lie group.
Basic recollections of rings, integral domains, Fields; Homomorphisms; Ideals and quotient rings; Maximal and prime ideals; Polynomial rings, Factorisation in R[x], Division algorithm, Gauss' lemma.

Field extensions; Algebraic extensions; Splitting fields. Finite fields.
The Galois group of a polynomial. The fundamental theorem of Galois theory.
Lattices*:*
Poset. Elementary properties of lattice. HasseDiagram.Modular and Distributive Latties.
Unit 2:
Partial Differential Equation:
First order PDEs: Cauchy problem for the linear first order equation and characteristics, linear and quasi-linear PDEs.

Second order PDEs: Classifications, fundamental solutions: Laplace, Wave and Diffusion equations.

Different methods of solving them: Methods of separation of variables for heat, Laplace and wave equations, method of characteristics, D'Alembert's solution to the wave equation and propagation of discontinuities, introduction to Green's function method. Maximum-minimum principles.

Nonlinear PDEs: Conversion to the linear form. Travelling wave solutions. Burger's, K-dV and nonlinear Schrodinger equations.

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Reference Books :

1. I.N. Herstein, Abstract Algebra, Macmillan, New York, 1990.
2. J.B. Fraleigh, A first in Abstract Algebra, Narosa, New Delhi, 1986.
3. N. Jacobson, Basic Algebra, vol.1 and 2, Hindusthan, New Delhi, 1984.
4. Sneddon I.N. : Elements of Partial Differential Equations, Mcgraw Hill.
5. Rao, K. S.: Partial differential equations.
6. Williams W.E. : Partial Differential Equations.
7. Miller F.H. : Partial Differential Equations
8. Petrovsky. I.G : Lectures on Partial differential equations.
9. Courant and Hilbert : Methods of Mathematical Physics, Vol – II

Course outcome:

After studying this course, the student is expected to be able to:

CO1: **understand** and use the properties of group theory
CO2: **Demonstrate** when a binary algebraic structure forms a group..
CO3: **solve** various problems related to group theory.

CO4: **explains** the notion of partial differential equations; explains the meaning of solution of a partial differential equation.
CO5: **classify** partial differential equations and transform into canonical form
CO6: **solve** PDE problems in different ways.

Course CC2: REAL ANALYSIS AND GENERALIZED FUNCTIONS
Credit 4: (3L-1T-0P)

Unit1 :
Real Analysis

Derivative Matrix and the Differential; Mean Value Theorem for General Mappings; Chain rule for general mappings; The inverse function and implicit function theorems for general mappings. The related examples.

Bounded and totally bounded metric spaces; Compact and separable metric spaces. Functions on metric spaces. Limit, continuity and uniform continuity. Contraction mapping. Banach fixed point theorem. Introductory concepts on Banach space, Hilbert space. Simple properties. Wierstrass approximation theorem.

Functions of bounded variation. Decomposition theorem, Derived function. Derivates. Absolute Continuity.

Trigonometric Fourier Series of Functions , convergence at a point. Cesarosummability of Fourier series. Fourier series in Hilbert spaces.

Unit 2:
Generalized functions:

Bolzano-Weierstrass theorem, classes of functions, space of the test functions, space of the generalized functions. Support of the generalized functions, regular generalized functions, properties. Singular generalized functions, Principle part of 1/x. Plancherele's formula. Change of the variables in generalized functions, multiplication of the generalized functions, differentiation of the generalized functions, properties of generalized derivatives.

General solution of $x^m u = 0$, general solution of $u^m(x) = 0$. Convolution of generalized functions (statement only), problems. Space of the test function of rapid decay. Functions of slow growth, generalized function of slow growth, Fourier transform of generalized function of slow growth, Fourier transform of the Heaviside function, Poisson's sum formula.

Reference Books:

1. H.L. Royden, Real Analysis, 3rd ed., Macmillan Publishing Co., Inc., New York, 1989.
2. E.C. Titchmarsh, Theory of Functions, Clarendon Press, 1932.
3. T.M. Apostal, Mathematical Analysis, Wesley, Reading, 1974.
4. I.P. Natanson, Theory of Functions of a Real Variable, Vols. I & II, Akademie-Verlag, Berlin, 1981.
5. Methods of the theory of Generalized functions – V. S. Vladimirov
6. A collection of problems on the equations of mathematical physics - V. S. Vladimirov

Course outcome:

After attending the course students will be able to:

CO1: **understand** the ideas of total variation of a function and to be able to deal with the functions of bounded variation.

CO2: **develop** the ability to deal with the problems which are quite significant in the field of real analysis.

CO3: **apply** the fundamental theorems and principles to solve the complex mathematical problems.

CO4: **demonstrate** knowledge of generalized functions and distributions.

CO5: **analyze** the function in a more generalized sense using suitable test functions

CO6: **Formulate** complex mathematical problems using the notion of generalized functions.

Course CC3: COMPLEX ANALYSIS AND ORDNARY DIFFERENTIAL EQUATIONS
Credit 4: (3L-1T-0P)

Unit 1: Complex Analysis:

Complex numbers, Topology of the complex plane, sequence of complex numbers, Stereographic projection. Analytic functions, Cauchy-Riemann equations, Zeros of analytic functions, Multiple valued functions, Branch cuts, Concept of Riemann sheet. Curves in the complex plane, Complex integration, Jordan's Lemma. Cauchy's theorem, Morera's theorem, Cauchy integral formula, Maximum modulus principle, Open mapping Theorem, Schwarz Lemma, Liouville's theorem, Fundamental theorem of algebra. Series, Uniform convergence, Properties of uniformly convergent series, Power series, Taylor series, Uniquenss theorem, Analytic continuation, Laurent series. Singularities, Classification of singularities, Cauchy's residue theorem. Evaluation of some integrals, Argument principle. Conformal mapping, Mobius transformation.

Unit 2: Ordinary Differential Equations:

Theory of Ordinary Differential Equations: (20 marks) Existence and Uniqueness of solutions of initial value problems for first order ordinary differential equations, Singular solutions of first order ODEs. Linear homogeneous differential equation: Ordinary and singular points, Series solution, Method of Frobenius, Fuch's theorem, Equations of Fuchsian type. Linear non-homogeneous differential equation: Solution by variation of parameters, Strum - Liouville's equation. Eigen value problem and the variational method. Completeness of eigenfunctions. Integral representation and Green's function. System of ODE's Flow diagram, Phase portrait, Isocline. Fixed points and their nature. stability, asymptotic stability, Liapunov function, Linearization at a critical point. Legendre function. Rodrigues formula. Orthogonal property. Recurrence relations. Bessel function. Orthogonal property. Recurrence relations.

Reference Books:

1. E.T. Copson, An introduction to theory of functions of a complex variable, Oxford, Clarendon Press, 1962.
2. E.T. Whittaker and G.N. Watson, A course of modern analysis, Cambridge University Press, 1958.
3. R.V. Churchill, J.W. Brown and R.E. Vermay, Complex variables and applications, McGraw Hill, 1984.
4. T.M. MacRobert, Functions of a complex variable, MacMillan, 1962.
5. I.N. Sneddon, Special functions of Mathematical Physics and Chemistry, Longman, 1980.
6. E.A. Coddington and N. Levison, Theory of Ordinary Differential Equations, Tata McGraw Hill, 1955.
7. E.L. Ince, Ordinary Differential Equations, Dover, 1956.
8. E.D. Rainville, Special Functions, MacMillan, 1960.
9. N.N. Labedev, Special Functions, and their applications, Dover, 1972.

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10. L.V. Ahlfors, Complex Analysis, McGraw Hill, 1978.
11. M.J. Ablowitz, Complex Variables: Introduction and Applications, Cambridge University Press, 1997.
12. W. Rudin, Real and Complex Analysis, McGraw Hill, 1986.
13. H.A. Priestley, Introduction to complex analysis, Indian Edition, 2006.
14. J.B. Conway, Functions of one complex variable I and II, Springer-Verlag, New York, 2005 and 1995

Course outcome:

After attending the course students will be able to:

CO1 Apply differential equations to variety of problems in diversified fields of life.

CO2 Learn use of differential equations for modelling and solving real life problems.

CO3 Interpret the obtained solutions in terms of the physical quantities involved in the original problem under reference.

CO4 Use various methods of approximation to get qualitative information about the general behaviour of the solutions of various problems.

CO5: Apply the knowledge of complex integration to solve various improper integrals.

CO6: Apply the knowledge of complex variable function to solve different complex problems

Course CC4: INTRODUCTION TO CONTINUUM MECHANICS
Credit 4: (3L-1T-0P)

Cartesian Tensor

Deformation of Continuum: Lagrangian and Eulerian methods of describing deformation, finite strain deformation, infinitesimal strain tensor, infinitesimal stretch and rotation, change in volume.

Analysis of Strain : Relative displacement, strain quadratic, principal strains, strain invariants, compatibility conditions.

Analysis of Stress : Body forces, and surface forces, stress tensor, normal and shearing stresses, principal stress, stress invariants.Stress equations of equilibrium and motion, Symmetry of stress tensor.

Generalized Hooke's Law : Strain energy, Generalized Hooke's Law, Isotropic elastic solid, Elastic moduli for isotropic media, Beltrami-Michel compatibility equations.

Fluid : Basic concept of fluid, classification of fluids, constitutive equations, equations of motion of fluid , stream lines, path line and vortex lines, circulation and vorticity.

Inviscid Incompressible Fluid : Equation of continuity, constitutive equation of perfect fluid and viscous fluid, Euler's equation of motion, integrals of Euler's equation of motion, Bernoulli's equation, Kelvin's minimum energy theorem, Sources and sinks and doublets.

Viscous Incompressible Fluid : Governing equations, Navier Stroke's equations, flow between parallel plates.

Reference Books:

1. G. E. Mase: Theory and Problems of Continuum Mechanics, Schaum's Outline Series, Mc GrawHill Book Company.
2. R. N. Chatterjee: Mathematical Theory of Continuum Mechanics, Narosa.
3. J. N. Reddy: Princilpes of Continuum Mechanics, Cambridge University Press.
4. Y. C. Fung : A first course in Continuum Mechanics, Prentice Hall.
5. R. C. Batra: Elements of Continuum Mechanics, AIAA.
6. W. M. Lai, D. Rubin, E. Krempl, Continuum Mechanics, Butterworth Heinemann,
7. S. Nair: Introduction to Continuum Mechanics, Cambridge University Press.

8. J. L. Wegner, J. B. Haddow: Elements of Continuum Mechanics and Thermodynamics, Cambridge University Press.
9. D. S. Chandrasekharaih and L. Debnath, Continuum Mechanics, Academic Press, 1994. Inc..
10. T. J. Chung: Applied Continuum Mechanics, Cambridge University Press.
11. A.C. Eringen: Mechanics of continua, Robert E. Krieger Publishing Company, INC.
12. L. E. Malvern: Introduction to the Mechanics of a continuous medium, Prentice-Hall,
13. L.I. Sedov :Intoduction to the Mechanics of a Continuous Medium, Addison Wesley Publishing Company, INC.

***Course outcome*:**

After attending the course students will be able to:

CO1: **understand** the basic difference between Lagrangian and Eulerian method of describing finite and infinitesimal deformationin solid and fluid media. The principal strain and principal stress, compatibility conditions, stream line, path line, vortex motion, compressible and incompressible fluid. Equation of continuity, equation of motion. Different types of elastic moduli, strain energy function , viscous and non viscous fluid.
CO2: **solve** the principal strain , stress and corresponding directions when the strain tensor and stress tensor respectively given. Solve for whether the motion is irrotational or rotational.
CO3: **Evaluate** the constitutive equations for isotropic homogeneous linearly viscous compressible fluid, the flow between two parallel plates (plane Poiseuille flow, Couette flow),
CO4: **Evaluate** the velocity potential when the velocity field is given, Beltrami Michell compatibity equations.
CO5: determine the constancy of circulation for both perfect incompressible fluid and viscous fluid.
CO6: Derive stream line. Path line, vortex lines when the velocity field is given.

Course CC5: DISCRETE MATHEMATICS, GRAPH THEORY AND NONLINEAR DYNAMICS
Credit 4: (3L-1T-0P)

Unit 1:

Propositional Logic: Propositional Equivalence; Predicates and Quantifiers; Method of Proof; Normal forms; Applications.
Pigeon-hole principle, Pascal triangle, Principle of inclusion and exclusion. Generating functions, Recurrence relation.
Partially ordered sets. Lattices. Distributive and complete lattices. Dilworth's theorem on poset. Applications.
Switching Circuit: Minimization Problems. Clocks, Flip-flops.

Diagram of binary relation; Basic definitions; Matrix representations.

Unit 2:

Graphs and examples, Paths, Cycles, Radius, Diameter, Girth, Circumference; Weighted distance metric; Euler Walk, Hamiltonian cycle.
Connectivity, Sub-graphs, Isomorphism.
Properties of Tree, Rooted binary tree, Spanning trees, Prim's algorithm. Kruskal's Algorithm.
Linear spaces associated with graphs; cycle subspace, Cut-set subspace. Relation between bases and spanning trees.

Graph colouring, Chromatic number, Gurthrie's four colour problem and Heawood's five colour map (statement only).
Planarity, Crossing number, Kuratowski's theorem (statement only).
Directed graph, Network flow, Max-flow Min-cut theorem (statement only); Ford and Fulkerson algorithm.

Unit 3:

Flows on a line: Introduction – Fixed Points and Stability. Population Growth, diverstability, Analysis, Impossibility of Oscillation, Potentials.
Bifurcation: Introduction, Saddle-Node Bifurcation, Transcritical Bifurcation-Pitchfork Bifurcation. Imperfect Bifurcation and Catastrophes, Insect Outbreak.

Reference Books:

1. I.M. Copi, Symbolic Logic, Prentice Hall of India.
2. K.H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw Hill.
3. Rene Cori and Daniel Lascar, Mathematical Logic, A Course with Exercise, Oxford University Press.
4. C.L. Chang and Lee, Mechanical Theorem Proving, Academic Press.
5. T.C. Bartee, Digital Computer Fundamentals, Tata McGraw Hill.
6. D.D. Givone, Introduction to Switching Circuit Theory, McGraw Hill Book Company.
7. J.L. Gross and J. Yellen, Graph Theory and its applications, CRC Press, 2005.
8. S.H. Strogatz, Non-linear Dynamics and Chaos, Addison-Wesley Publ. Co., New York, (1994).

***Course learning outcome*:** On completion of the course, the student should be able to:

1. know some important classes of graph theoretic problems;
2. formulate and prove central theorems about trees, matching, connectivity, colouring and planar graphs;
3. describe and apply some basic algorithms for graphs;
4. use graph theory as a modelling tool.
5. analyze the behavior of dynamical systems (e.g. find periodic orbits and assess their stability, draw phase portraits, etc.) expressed as either a discrete-time mapping or a continuous-time flow,
6. apply the techniques of nonlinear dynamics to physical processes drawn from a variety of scientific and engineering disciplines,
7. analyze changes (i.e. bifurcations) to dynamical systems as system parameters are varied,
8. analyse various chaotic applications in real-life systems, say engineering and biomedical applications, control and synchronise them as per requirement,

Course: LINEAR MODELS
Credit 4: (3L-1T-0P)

UNIT I: Basic Ideas of Linear Algebra [16L]
A brief review of linear algebra: vector and vector spaces, span, spanning set, linear dependence independence and basis. Orthogonal vectors and ortho-complement spaces, orthogonal projection of vectors. Matrices, row space, column space and null space of a matrix, characteristics roots and vectors of square matrices, quadratic forms and their canonical reduction, g-inverse and its properties.
UNIT II: Linear Statistical Inference [16L]
Gauss-Markov model: Estimation space and error space, estimable functions, error functions, BLUE and related results, Least Square estimation, Gauss-Markov Theorem. Sum of squares due to a test of linear functions. General Linear Hypothesis problem, description of F test for a general linear hypothesis (without proof). Linear models for correlated errors.
UNIT III: Different Linear Models [16L]
ANOVA: fixed, random and mixed effects model, simple and multiple linear regression models, ANCOVA, Multiple comparison, S-method and T-method of multiple comparison.

Text & Reference books:
1 Gun A.M., Gupta M.K. and Dasgupta B. (2002): Fundamentals of Statistics, Vol. II, 8th Edition, The World Press Private Limited, Kolkata.
2 Scheffe H. (1959): The Analysis of Variance, John Wiley.
3 Rao C.R. (2009): Linear Statistical Inference and its Applications, 2nd Edition, John Wiley & Son, Inc.
4 Faraway J.J. (2014): Linear Models with R, 2nd Edition, CRC Press.
5 Gupta S.C. and Kapoor V.K. (1975): Fundamentals of Applied Statistics: A Modern Approach, S. Chand & Company.

Course learning outcomes:
CO1: **Demonstrate** the concepts of vector subspaces, orthogonal projection, row-space, column-space, g-inverse etc.
CO2: **Make use of** the knowledge of Gauss-Markov theorem in finding BLUEs.
CO3: **Explain** the fundamental concepts of testing general linear hypothesis, orthogonal splitting and valid error.
CO4: **Apply** the knowledge of different tests in simple and multiple regression set-up.
CO5: **Construct** analysis of variance models to test the significance of several means.
CO6: **Construct** analysis of covariance models to test the significance of several means.

Course CC6: NUMERICAL ANALYSIS
Credit 4: (3L-1T-4P)

1. Computer Number System: Control of round-off-errors, Instabilities – Inherent and Induced, Hazards in approximate computations, Well posed computations, Well-posed and Ill-posed problems, The direct and inverse and identification problems of computation.

2. Numerical Solution of System of Linear Equations: Triangular factorisation methods, Matrix inversion method, Operation counts, Iterative methods – Jacobi method, Convergence condition of Gauss-Seidel method and Gauss-Jacobi method, Importance of diagonal dominance, Successive-Over-Relaxation (SOR) method, Solution of over-determined system of linear equations – Least squares method, III conditioned matrix, Algorithms.

3. Eigenvalues and Eigenvectors of Real Matrix: Power method for extreme eigenvalues and related eigenvectors, Jacobi's method for symmetric matrix (algorithm only).

4. Solution of Non-linear Equations:

Single Equation: Modified Newton-Raphson method (for real roots-simple or repeated). Aitken's δ^2-method and Steffensen's iteration.

5. Roots of Real Polynomial Equations: Sensitivity of polynomial roots, Bairstow's method of quadratic factors, Quotient-difference method (algorithm only).

6. Non-Linear Systems of Equations: Newton's method, Quasi-Newton's method.

7. Polynomial Interpolation: Weirstrass's approximation theorem (Statement only), Runge's phenomena, Divergence of sequences of interpolation polynomials for equi-spaced interpolation points, piecewise polynomial inter-polation – Cubic spline interpolation, Convergence properties (statement only), Inverse interpolation, Numerical differentiation using equi-spaced points.

8. Approximation of Functions: Approximation with orthogonal polynomials, Chebyshev polynomials.

9. Numerical Integration: Problem of approximate quadrature, Gauss-Legendre and Gauss-chebyshevquadratures, Euler-Maclaurin summation formula, Richardson extrapolation, Romberg integration, Simpson's adaptive quadrature, Fredholm integral equation, Double integrals – Cubature formula of Simpson Type, Improper integrals.

10. Numerical Solution of Initial Value Problems for ODE:

First Order Equation: Runge-Kutta methods, Multistep predictor-corrector methods – Adams-Bashforth method, Adams-Moulton method, Milne's method, Convergence and stability.

11. Two-point Boundary Value Problems for ODE: Finite difference methods.

12. Numerical Solution of PDE by Finite Difference Methods: Parabolic equation in one dimension (Heat equation), Explicit finite difference method, Implicit Crank-Nicolson method, Elliptic Equations, Hyperbolic equation in one-space dimension (Wave Equation) – Finite difference method.

Numerical Analysis Lab

Jacobi method, Gauss-Seidel method and Gauss-Jacobi method, Successive-Over-Relaxation (SOR) method.

Power method for extreme eigenvalues and related eigenvectors.

Modified Newton-Raphson method (for real roots-simple or repeated).

Bairstow's method of quadratic factors, Quotient-difference method (algorithm only).

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Newton's method.

Finite difference methods : Parabolic equation in one dimension (Heat equation), Explicit finite difference method, Implicit Crank-Nicolson method, Elliptic Equations, Hyperbolic equation in one-space dimension (Wave Equation).

Reference Books:

1. A. Ralston, A First Course in Numerical Analysis, McGraw Hill, N.Y. ,1965.
2. A. Ralston and P. Rabinowitz, A First Course in Numerical Analysis, McGraw Hill, N.Y., 1978.
3. S.D. Conte and C. DeBoor, Elementary Numerical Analysis: An Algorithmic Approach, McGraw Hill, N.Y., 1980.
4. K.E. Atkinson, An Introduction to Numerical Analysis, John Wiley and Sons, 1989.
5. W.F. Ames, Numerical Methods for PDEs, Academic Press, N.Y., 1977.
6. L. Colatz, Functional Analysis and Numerical Mathematics, Academic Press, N.Y., 1966.

***Course outcome*:**

After attending the course students will be able to:

CO1: **understand** the error propagation in numerical analysis and implement it to the numerical computations.
CO2: **solve** the system of linear and nonlinear equations using suitable numerical techniques.
CO3: **Evaluate** the double integrals using suitable numerical technique.
CO4: **Evaluate** different types of initial value problems by suitable numerical technique.
CO5: **Formulate** a given physical problem in the form of PDE and solve it by suitable finite difference scheme.

Course CC7:
Credit 4: (3L-1T-0P) INTEGRAL TRASNFORMS AND INTEGRAL EQUATIONS

Integral transform:

Fourier Transform and its properties, Inversion formula of F.T.; Convolution Theorem; Parseval's relation. Applications.
Laplace's Transform and its properties. Inversion by analytic method and by Bromwitch path. Lerch's Theorem. Convolution Theorem; Applications.
Z-transform : Definition and properties. Z-transform of some standard functions. Inverse Z-transforms. Applications.
Wavelet Transforms:
Definition of wavelet, Examples, Window function, Windowed Fourier transform, Continuous wavelet transform, Discrete wavelet transform, Multiresolution analysis, Application to signal and image processing.

Integral Equations:

Reduction of boundary value problem of an ordinary differential equation to an integral equation. Fredholm equation: Solution by the method of successive approximation. Numann series. Existence and uniqueness of the solution of Fredholm equation. Equations with degenerate kernel. Eigen values and eigen solutions. Volterra equation: Solution

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by the method of iterated kernel, existence and uniqueness of solution. Solution of Abel equation. Solution of Volterra equation of convolution type by Laplace transform.

Reference Books:

1. I.N. Sneddon, Fourier Transform, McGraw Hill, 1951.
2. F.C. Titchmash, Introduction to the theory of Fourier Integrals, Oxford Press, 1937.
3. Peter, K.F. Kahfitting, Introduction to the Laplace Transform, Plenum Press, N.Y., 1980.
4. E.J. Watson, Laplace Transforms and Application, Van Nostland Reinhold Co. Ltd., 1981.
5. E.I. Jury, Theory and Application of Z-Transform, John Wiley and Sons, N.Y.
6. R.V. Churchill, Operational Mathematics, McGraw Hill, 1958.
7. D. Loknath, Integral Transforms and their Application, C.R.C. Press, 1995.
8. Introduction to Wavelet Transforms – Narasimhan, Basumallik and Veena
9. D. Porter and D.S.G. Stirling, Integral Equations, Cambridge University Press, 2004.
10. H. Hochstadt, Integral equations, Wiley-Interscience, 1989.
11. A. Wazwaz, A first course in integral equations, World Scientific, 1997.
12. F.G. Tricomi, Integral Equations, Dover, 1985.
13. Ram P. Kanwal, Linear Integral Equation – Theory and Technique, Academic Press, Inc.
14. W.V. Lovitt, Linear Integral Equations, Dover, New York.
15. S.G. Mikhlin, Integral Equations, Pergamon Press, Oxford.
16. N.I. Mushkhelishvili, Noordhoff, Singular Integral Equations, Gronignen, Holland.
17. W. Pogorzclski, Integral Equations and Their Application, Vol. I, Pergamon Press, Oxford.

Course Outcomes:

After attending this course the students will be able to
CO1: Understand the basic properties of different integral transforms (Laplace transform, Fourier transform).

CO2: Apply different integral transforms to the real life problems of Physics, Biology, and Engineering etc.

CO3: Formulate and **solve** complex engineering boundary value problems.

CO4: Discuss the properties of Z transform and Wavelet transform and its applications.

CO5: Identify the Fredholm and Volterra integral equations with different kind for different kernels.

CO6: Solve the problems of mechanics with the help of integral equations with different methods.

Course CC8: BASIC KNOWLEDGE OF PYTHON PROGRAMMING
Credit 4: (3L-1T-4P)

Unit 1: Introduction To Python -Installation and Working with Python Understanding Python variables Python basic Operators Understanding python blocks

Unit 2: Python Data Types -Declaring and using Numeric data types: int, float, complex Using string data type and

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string operations Defining list and list slicing Use of Tuple data type

Unit 3: Python Program Flow Control -Conditional blocks using if, else and elif Simple for loops in python For loop using ranges, string, list and dictionaries Use of while loops in python Loop manipulation using pass, continue, break and else Programming using Python conditional and loops block

Unit 4: Python Functions, Units And Packages -Organizing python codes using functions Organizing python projects into Units Importing own Unit as well as external modules Understanding Packages Powerful Lambda function in python Programming using functions, modules and external packages

Unit 5: Python String, List And Dictionary Manipulations -Building blocks of python programs Understanding string in build methods List manipulation using in build methods Dictionary manipulation Programming using string, list and dictionary in build functions

Unit 6: Python File Operation -Reading config files in python Writing log files in python Understanding read functions, read(), read line() and read lines() Understanding write functions, write() and write lines() Manipulating file pointer using seek Programming using file operations

Unit 7: Python Object Oriented Programming – Oops Concept of class, object and instances Constructor, class attributes and destructors Real time use of class in live projects Inheritance, overlapping and overloading operators Adding and retrieving dynamic attributes of classes Programming using Oops support

Unit 8: Python Regular Expression -Powerful pattern matching and searching Power of pattern searching using regex in python Real time parsing of networking or system data using regex Password, email, url validation using regular expression Pattern finding programs using regular expression

Unit 9: Python Exception Handling -Avoiding code break using exception handling safe guarding file operation using exception handling Handling and helping developer with error code Programming using Exception handling

Unit 10: Python Database Interaction -SQL Database connection using python Creating and searching tables Reading and storing config information on database Programming using database connections

Unit 11: Python Multithreading -Understanding threads Forking threads Synchronizing the threads Programming using multithreading

Unit 12: Contacting User Through Emails Using Python -Installing smtp python module Sending email Reading from file and sending emails to all users addressing them directly for marketing

Unit 13: Python CGI Introduction -Writing python program for CGI applications Creating menus and accessing files Server client program

Python Lab

References :

1. Python pocket reference – Mark Lutz
2. Python for data analysis – Wes McKinney

Course Outcome (CO):
CO1: Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements
CO2: Express proficiency in the handling of strings and functions.
CO3: Determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets.
CO4: Identify the commonly used operations involving file systems and regular expressions.
CO5: Articulate the Object-Oriented Programming concepts such as encapsulation, inheritance and polymorphism as used in Python.
CO6: Implement Conditionals and Loops for Python Programs knowledge/skill development and Use functions and represent Compound data using Lists, Tuples and Dictionaries

Course CC9: ELASTIC DEFORMATION
Credit 4: (3L-1T-4P)

Strains and rotations in orthogonal curvilinear coordinates. Determination of displacements from strain tensor. Stress equations of equilibrium and motion in orthogonal curvilinear coordinates. Anisotropic bodies. Stress-strain relations in anisotropic elasticity. Fundamental boundary value problems of elastostatics. Saint-Venant' principle. Saint-Venant'ssemi inverse method.
Plane strain, plane stress and generalized plane stress. Airy's stress function in rectangular and polar coordinates. Compatibility equations. Rotating disks and other simple problems. Complex representations of 2-space biharmonic functions and boundary conditions. Kolosov-Muskhelisvili formulae for displacement and strain in terms of potential functions. Structures of complex potentials in multi-connected regions. Conformal mapping method. Solutions of simple problems such as loaded infinite plane/regions weakened by a circular hole, infinite plane with an elliptic hole, concentrated force in an infinite plate.
Integro-differential equations of Muskhelisvili and their solutions for simple problems. Solutions of a boundary value problem for a half-space.
Stress-strain relations in Thermo elasticity. Reduction of statistical thermo-elastic problem to a problem of isothermal elasticity. Basic equations in dynamic thermoelasticity. Coupling of strain and temperature fields. Concepts of generalized thermoelasticity and related theories.

References:
1. I. S. Sokolnikoff: Mathematical Theory of Elasticity. McGraw Hill, 1956.
2. A. E. H. Love: A treatise on mathematical theory of elasticity. Dover, 1954.
3. P.L. Gould: Introduction to linear elasticity. Springer-Verlog, 1994.
4. N. I. Muskhelisvili: Some basic problems on the theory of elasticity. Nordhoff, 1953.
5. Y. C. Fung: Foundation of solid mechanics. Prentice Hall, 1965.
6. L. D. Landau and E. M. Lifshitz: Theory of Elasticity. Pergamon Press, 1989.
7. J. D. Achenbach: Wave Propagations in Elastic Solids, North Holland Publishing Company.
8. K. F. Graff: Wave Motion in Elastic Solids, Dover Publications Inc.
9. W. Nowacki. Thermoelasticity, Addison-Wesley Publishing Co., 1962.
10.W. Nowacki: Dynamic Problems of Thermoelasticity, Noordhoff International Publishing
11. J. L. Nowinski. Theory of thermoelasticity with applications. Sijthoff and Noardhaoff International Publishers, 1978.

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12. R. B. Hetnarski, M. R. Eslami : Thermal Stresses – Advanced Theory and Applications, Springer.
13. M. R. Eslami, R. B. Hetnarski, J. Ignaczak, N. Noda, N. Sumi, Y. Tanigawa: Theory of Elasticity and Thermal Stresses, Springer.
14. Ranjit S. Dhalwal and Avtar Singh. Dynamic Coupled Thermoelasticity, Hindustan Publishing Corporation, 1986.

Course learning outcome:
CO1: Analyze the behaviour of the solid bodies subject to various types of loading.
CO2: Apply knowledge of materials and structural elements to fracture mechanics problems.
CO3: Understand problem identification, formulation and solution using analytical methods of elastic problems.
CO4: Understand the concept of thermo-elasticity associated with solid mechanics.
CO5: understand the stress strain deformation of an elastic body.
CO5: Solve complex problem of mechanics using the fundamental principles of elastostatics.
Pedagogy for Course Delivery: *Chalk, Board, Study Materials, pictures.*
List of Professional Skill Development Activities (PSDA): *N/A*
Continuous assessment: Quiz/assessment/presentation/problem solving etc.

Course CC10: MANAGEMENT INFORMATION SYSTEM
Credit 3: (3L-0T-0P)

Module 1 INTRODUCTION: Technology of Information Systems, concepts, definition; role and impactof MIS; role and importance of management; approaches to management; functions of the manager;management as a control system; concepts of data models; database design; client-server architecture.

Module 2 PROCESS OF MANAGEMENT: Planning, organization, staffing, coordination and controlling;management by exception; MIS as a support to management; organization structure and theory; basicmodel and organization structure; organizational behavior.

Module 3 DECSION MAKING AND INFORMATION: Decision making concepts, methods, tools andprocedures; behavioral concepts in decision making; organizational decision making; informationoncepts as a quality product; classification of the information; methods of data and informationcollection; value of the information; organization and information system concepts, control types;handling system complexity; post implementation problems in systems.

Module 4 SYSTEM ANALYSIS AND DESIGN: Need for system analysis; system analysis of existingsystem; new requirement; system development model; structured system analysis and design; computersystem design; development of MIS; development of long range plans of the MIS; ascertaining the classof the information; determining the information requirement; development and implementation of theMIS; management of quality; MIS factors of success and failure.

Module 5 DECISION SUPPORT SYSTEMS: Deterministic systems; artificial intelligence; knowledgebased systems; MIS and the role of DSS; enterprise management systems; enterprise resource planning(ERP); ERP features and benefits; implementation factors of ERP; Internet and Web based informationsystem; Electronic Commerce.

Reference:

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Management Information Systems, G. B. Davis, M. H. Olson, McGraw Hill,1998.

Course CC11: TOPOLOGY, FUNCTIONAL ANALYSIS AND OPERATOR THEORY
Credit 4: (3L-1T-0P)

Unit 1
Topological spaces: Elementary concepts, continuity, convergence, homeo-morphism. Open bases and open subbases. Weak topologies. First and second countability, Separable spaces.
Compactness, Connectedness, Local and Path connectedness, Separation axioms, Urysohn's Lemma and Tietze extension Theorem. Subspaces, Product Spaces, Quotient spaces. Tychonoff's theorem. Metrizability, Paracompactness and Urysohn'sMetrization Theorem.

Unit 2
Linear spaces: Normed linear spaces, Linear topological spaces, Banach spaces, Hilbert spaces, Orthogonality in Hilbert spaces and related theorems (Orthogonal Projection Theorem; Best Approximation; Generalized Fourier Series; Bessel's Inequality; Complete Orthonormal set; Perseval's Theorem).
Linear functionals: Dual spaces, reflexive property, Hahn-Banach extension theorem, Representation of linear functionals on Hilbert spaces (Riesz-representation theorem), strong and weak convergences of a sequence of elements and of a sequence of functionals. Weak topologies in Banach spaces. Banach-Alaoglu theorem.

Unit3
Linear operators: Linear operators in normed linear spaces, uniform and point wise convergence of operators; Banach-Steinhaus theorem. Uniform boundedness theorem. Open mapping theorem. Bounded inverse theorem. Closed linear operators, Closed graph theorem, Adjoint operator, Self-adjoint operators; Normal and Unitary operators; Compact symmetric operator; Hilbert-Schmidt theorem, Eigenvalues and their properties. Spectral theorem for bounded normal operators. Linear integral operator, Fredholm and Volterra type. Fredholm alternative.

Reference Books:
1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, Singapore, 1963.
2. J.R. Munkres, Topology, A First Course, Prentice-Hall of India Pvt. Ltd., New Delhi, 2000.
3. H.L. Royden, Real Analysis, 4th ed., Macmillan Pub. Co., New York, 1993.
4. J.L. Kelley, General Topology, Von Nostrand, New York, 1995.
5. J. Dugundji, Topology, Allyn and Bacon, 1966 (Reprinted by PHI, India).
6. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, New York, 1978.

***Course outcome*:**
After studying this course, the student is expected to be able to:
CO1: **demonstrate** the use of cell phones to actually map out the topology of indoor spaces.
CO2: **Explain** the fundamental concepts of functional analysis and their role in modern mathematics and applied contexts

CO3: **Demonstrate** accurate and efficient use of functional analysis techniques.
CO4: **Demonstrate** capacity for mathematical reasoning through analysing, proving and explaining concepts from functional analysis.
CO5: **Apply** problem-solving using functional analysis techniques applied to diverse situations in physics, engineering and other mathematical contexts.
CO6: **Explain** the fundamental concepts of operator theory and their role in modern mathematics and applied contexts

Course CC12: CRYPTOGRAPHY AND NETWORK SECURITY
Credit 4: (3L-1T-0P)

Unit 1(9L): INTRODUCTION & NUMBER THEORY
Services, Mechanisms and attacks-the OSI security architecture-Network security model-Classical Encryption techniques (Symmetric cipher model, substitution techniques, transposition techniques, steganography).FINITE FIELDS AND NUMBER THEORY: Groups, Rings, Fields-Modular arithmetic-Euclid's algorithm-Finite fields- Polynomial Arithmetic –Prime numbers-Fermat‟s and Euler‟s theorem-Testing for primality -The Chinese remainder theorem- Discrete logarithms.

Unit 2(10L): BLOCK CIPHERS & PUBLIC KEY CRYPTOGRAPHY
Data Encryption Standard-Block cipher principles-block cipher modes of operation-Advanced Encryption Standard (AES)-Triple DES-Blowfish-RC5 algorithm. Public key cryptography: Principles of public key cryptosystems-The RSA algorithm-Key management – Diffie Hellman Key exchange-Elliptic curve arithmetic-Elliptic curve cryptography.

Unit 3(8L): HASH FUNCTIONS AND DIGITAL SIGNATURES
Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC –MD5 – SHA – HMAC – CMAC – Digital signature and authentication protocols – DSS – EI Gamal– Schnorr.

Unit 4(8L): SECURITY PRACTICE & SYSTEM SECURITY 8L
Authentication applications – Kerberos – X.509 Authentication services – Internet Firewalls for Trusted System: Roles of Firewalls – Firewall related terminology- Types of Firewalls – Firewall designs – SET for E-commerce Transactions. Intruder – Intrusion detection system – Virus and related threats –Countermeasures – Firewalls design principles – Trusted systems – Practical implementation of cryptography and security.

Unit 5 (8L): E-MAIL, IP & WEB SECURITY 9L
E-mail Security: Security Services for E-mail-attacks possible through E-mail – establishing keys privacy authentication of the source-Message Integrity-Non-repudiation-Pretty Good Privacy-S/MIME. IP Security: Overview of IPSec – IP and IPv6-Authentication Header-Encapsulation Security Payload (ESP)-Internet K Exchange (Phases of IKE, ISAKMP/IKE Encoding). Web Security: SSL/TLS Basic Protocol-computing the keys-client authentication-PKI as deployed by SSL Attacks fixed in v3- Exportability-Encoding-Secure Electronic Transaction (SET).

References:
1. C K Shyamala, N Harini and Dr. T R Padmanabhan: Cryptography and Network Security, Wiley India Pvt.Ltd

2. BehrouzA.Foruzan, Cryptography and Network Security, Tata McGraw Hill 2007.
3. Charlie Kaufman, Radia Perlman, and Mike Speciner, Network Security: PRIVATE Communication in a PUBLIC World, Prentice Hall, ISBN 0-13-046019-2

Course Outcome (CO):
CO1: Understand the most common type of cryptographic algorithm and understand the Public-Key Infrastructure
CO2: Understand security protocols for protecting data on networks
CO3: Be able to digitally sign emails and files and understand vulnerability assessments and the weakness of using passwords for authentication
CO4: Be able to perform simple vulnerability assessments and password audits
CO5: Be able to configure simple firewall architectures
CO6: Understand Virtual Private Networks

Course CC13: OPTIMIZATION AND OPERATIONS RESEARCH
Credit 4: (3L-1T-0P)

Linear programming, Revisedsimplex method, Dual simplex method, Post optimal analysis.

Nonlinear programming, Karush-Kuhn-Tucker necessary and sufficient conditions of optimality, Quadratic programming, Wolfe's method, Beale's method.

Dynamic programming, Bellman's principle of optimality, Recursive relations, System with more than one constraint, Solution of LPP using dynamic Programming.

Inter programming, Gomory's cutting plane method, Branch and bound technique.

Inventory control, Concept of EOQ, Problem of EOQ with finite rate of replenishment, Problem of EOQ with shortages, Multi-item deterministic problem, Probabilistic invontory models.
Network Analysis: Network definition and Network diagram, probability in PERT analysis, project time cost trade off, introduction to resource smoothing and allocation.

Sequencing: Introduction, processing N jobs through two machines, processing N jobs through three machines, processing N jobs through m machines.

Queuing Models: Concepts relating to queuing systems, basic elements of queuing model, role of Poison & exponential distribution, concepts of birth and death process.
Replacement & Maintenance Models: Replacement of items, subject to deterioration of items subject to random failure group vs. individual replacement policies.

Simulation: Introduction & steps of simulation method, distribution functions and random number generation.

Elements of Fuzzy set theory and its relevance in representing uncertainties, Fuzzy linear programming.

References:

1. C. Hu, Integer Programming and Network Flows, Addison-Wesley, 1970.
2. G. Hadley, Nonlinear and Dynamic Programming, Addison-Wesley, 1972.
3. H.A. Taha, Operations Research, MacMillan Publ., 1982.
4. R.C. Pfaffenberger and D.A. Walker, Mathematical Programming for Economics and Business, The Iowa State University Press, 1976.
5. M.S. Bazaraa, H.D. Sherali, C.M. Shetty, Nonlinear Programming, J. Wiley & Sons.
6. D.N. Burghes and A.M. Downs, Modern Introduction to Classical Mechanics & Control, Ellis Horwood Publisher, Chichester, 1975.
7. M.D. Intriligator, Mathematical Optimization & Economic Theory, Prentice-Hall, Inc., 1971.
8. A. Kandel and S.C. Lee, Fuzzy Switching and Automata, Theory and Applications, Crane, Russak and Company, Inc., 1979.
9. H.J. Zimmerman, Fuzzy Programming and Linear Programming with Several Objective Functions, Fuzzy Sets & Systems I, pp. 45-55, 1978.
10. J.C. Pant, Introduction to Optimization, New Delhi, Jain Brothers, 1983

***Course outcome**:*

After studying this course, the student is expected to be able to:

CO 1: **Identify** appropriate optimization method to solve complex problems involved in various industries.
CO 2: **Demonstrate** the optimized material distribution schedule using transportation model to minimize total distribution cost.
CO 3: **understand** the appropriate algorithm for allocation of resources to optimize the process of assignment.
CO 4: **Explain** the theoretical workings of sequencing techniques for effective scheduling of jobs on machines.
CO 5: **Apply** the knowledge of game theory concepts to articulate real-world competitive situations to identify strategic decisions to counter the consequences.
CO 6: **Demonstrate** the various selective inventory control models to analyse and optimize inventory systems.

Course CC14: MACHINE LEARNING
Credit 4: (3L-1T-0P)

1. Introduction to Machine Learning (ML); Relationship between ML and human learning; A quick survey of major models of how machines learn; Example applications of ML
2. Classification: Supervised Learning; The problem of classification; Feature engineering; Training and testing classifier models; Cross-validation; Model evaluation (precision, recall, F1-mesure, accuracy, area under curve); Statistical decision theory including discriminant functions and decision surfaces; Naive Bayes classification; Bayesian networks; Decision Tree and Random Forests; k-Nearest neighbor classification; Support Vector Machines; Artificial neural networks including back propagation; Applications of classifications; Ensembles of classifiers including bagging and boosting
3. Hidden Markov Models (HMM) with forward-backward and Vierbi algorithms; Sequence classification using HMM; Conditional random fields; Applications of sequence classification such as part-of-speech tagging

4. Regression: Multi-variable regression; Model evaluation; Least squares regression; Regularization; LASSO; Applications of regression
5. Association rule mining algorithms including apriori
6. Expectation-Maximization (EM) algorithm for unsupervised learning
7. Clustering: average linkage; Ward's algorithm; Minimum spanning tree clustering; K-nearest neighbors clustering; BIRCH; CURE; DBSCAN
8. Anomaly and outlier detection methods

Lab Sessions:

(1) Introduction to WEKA and R
(2) Classification of some public domain datasets in UCI ML repository

References:

1. R.O. Duda, P.E. Hart, D.G. Stork, **Pattern Classification**, 2/e, Wiley, 2001.
2. C. Bishop, **Pattern Recognition and Machine Learning**, Springer, 2007.
3. E. Alpaydin, **Introduction to Machine Learning**, 3/e, Prentice-Hall, 2014.
4. A. Rostamizadeh, A. Talwalkar, M. Mohri, **Foundations of Machine Learning**, MIT Press.
5. A. Webb, **Statistical Pattern Recognition**, 3/e, Wiley, 2011.

The objective of the course is

CO1: To understand the basic theory underlying machine learning.
CO2: To be able to formulate machine learning problems corresponding to different applications.
CO3: To understand a range of machine learning algorithms along with their strengths and weaknesses.
CO4: To be able to apply machine learning algorithms to solve problems of moderate complexity.
CO5: To apply the algorithms to a real-world problem, optimize the models learned and report on the expected accuracy that can be achieved by applying the models.

Prerequisite: Knowledge of Artificial Intelligence

Course CC15: FINANCIAL MATHEMATICS AND BIOMATHEMATICS
Credit 4: (3L-1T-0P)

Unit 1
Financial Mathematics

Brownian motion, Geometric Brownian motion, interest rates and present Value analysis ; rate of return ; pricing via arbitrage, risk-natural probabilities, multi-period binomial theorem, Arbitrage theorem .
Black-Scholes formula, properties of Black-Scholes option cost, Delta-Hedging arbitrage Strategy.
Pricing for American put options, Valuing investment by expected utility, risk-averse, risk-neutral, log utility function, portfolio selection problem, value and conditional value at risk, capital assets pricing model, mean Variance analysis of risk-neutral-priced call option, Conditional value at risks.

Unit 2
Biomathematics

Basic Concepts of Ecology: Some fundamental concepts, Mathematical modelling, types of models, limitation of the models, Discrete-Time and Continuous-Time Dynamical Models.

Single species models(Non-age Structured): Exponential and logistic growth models and their solution.

Single species models(Age Structured): Continuous- time model, Lotka Integral equation, Solution

Mathematical models in Epidemiology: Basic concepts, SI model, formulation, solutions, SIS model with constant coefficient, formulation and solution, Some examples.

References:

1. An Elementary Introduction to Mathematical Finance –S.M. Ross
2. An Introduction to Mathematics of Financial Derivatives –S.N. Neftchi
3. Mathematics of Financial Markets –R.J. Elliot and P.E. Kopp
3. J.D. Murray (2001). Mathematical Biology, Vol.I& II, Springer-Verlag.
4. Mark Kot (2001). Elements of Mathematical Ecology, Cambridge University Press.
5. Bhupendra Singh and N. Agrawal (2008), Bio-Mathematics, Krishna Prakash Media (P) Ltd.

***Course outcome**:*

After attending the course students will be able to:

CO1: **understand** what are options (call option and put option), exercise price, exercise time.

CO2: **solve** the problem based on Geometric Brownian motion, time needed to double the money if interest rate is given..

CO3: **Evaluate**put–call option parity formula, option price for the Multiperiod Binomial Model, Black sholes formula for evaluating option price when there is no arbitrage.

CO4: **Evaluate** a betting scheme that results in a sure win from an experiment with three possible outcomes and odds are given.

CO5: **Formulate** the call option parity formula, Black sholes formula .the optimal portfolio when employing the utility function

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