DEBRAJ ROY COLLEGE (AUTONOMOUS)

POST GRADUATE SYLLABUS

M.A./M.Sc. in Mathematics

Department of Mathematics
Debraj Roy College
(An Autonomous College under Dibrugarh University)
Circuit House Road, Golaghat-785621(Assam)

	Core(Fix)	DSE(any one)	GE	AEC	TOTAL
Sem I	1. Abstract Algebra (4 Credit)	1. Tensor & Classical Mechanics (4 Credit)	-	1 Course X 2 Credit= 2	18
	2. Differential Equations (4 Credit)	2. Combinatorics and Probability (4 Credit)			
	3. Real Analysis (4 Credit)				
Sem II	1. Complex Analysis (4 Credit)	1. Magneto hydrodynamics (4 Credit)	Foundation in Mathematics (4 Credit)	-	20
	2. Linear Algebra (4 Credit)	2. Fuzzy Set Theory (4 Credit)			
	3. Numerical Analysis (4 Credit)	3. Non-linear Dynamical System and Chaos (4 Credit)			
		4. Operations Research (4 Credit)			
		5.Mathematical Biology (4 Credit)			
Sem III	1. Functional Analysis (4 Credit)	1. Advanced Algebra (4 Credit)	Mathematical Modelling (4 Credit)	1 Course X 2 Credit= 2	22
	2. Graph Theory (4 Credit)	2. Dempster-Shafer Theory of Evidence (4 Credit)			
	3. Numerical Partial Differential Equation (4 Credit)	3. Fluid Dynamics (4 Credit)			
		4. Network Science (4 Credit)			
Sem IV	1. Mathematical Methods (4 Credit)	1. Algebraic Graph Theory (4 Credit)	-	-	20
	2. Mathematical Modelling (4 Credit)	2. Computational Fluid Dynamics (4 Credit)			
	3. Measure Theory (4 Credit)	3. Game Theory (4 Credit)			
	4. Mathematics Teaching (4 Credit) OR Dissertation (4 Credit)	4. Topology (4 Credit)			
		5. Wavelet Analysis (4 Credit) -- -- 20 Total Credit 8			
Total Credit					80

Department of Mathematics: Debraj Roy College
Title of the Course: Abstract Algebra
Paper Number: 1C1
Category : CORE
Year 1
Credits 4
Course Code: MTHC1
Semester I
Instructional Hours (Per week)
Lecture3 Tutorial 1 Lab Practical 0 Total 4

Objectives of the Course	The students are expected to develop a strong foundation in Algebra with special emphasis on finite groups and algebraic number theory.
Learning Outcome	After going through this course the students will be able to (i) Describe the Group theoretic notions of class equation and the related results. (ii) (ii) Discuss three important classes of Ring structures, viz., the Principal ideal Domain, Euclidean domain and the unique factorization domain.
Course Outline	**Unit I:** A brief review of groups, their properties and examples, subgroups, isomorphism theorems, symmetric, alternating and dihedral groups. **Marks: 10 L :8 , T: 2** **Unit II:** Group action, The class equation of finite groups, Sylow theorems, Direct products of groups. **Marks: 15 L :11 , T:4** **Unit III:** A brief review of Rings, properties and examples. Ideals, Homomorphism and Quotient Rings, Field of quotients of an Integral Domain, Unique factorization domain, Principal Ideal Domain, Euclidean Domain. **Marks: 15 L :11 , T: 4** **Unit IV:** Extension fields; The fundamental theorem of Field Theory, Splitting Fields, Zeros of an irreducible Polynomial. Classification of Finite Field, Structure of Finite Fields, Subfields of a Finite Field. **Marks: 20 L :15 , T: 5**
Recommended Text	1. Herstein, I. N. (1975). Topics in Algebra Wiley. Eastern Limited. 2. Dummit, D. S., Foote, R. M. (2004). Abstract Algebra. Hoboken: Wiley.+ 3. Gallian, J. A.(2013). Contemporary Abstract Algebra, New Age International.
Reference Books	1. Hungerford, T. W., Algebra. (1974). Springer-Verlag. New York. 2. Bhattacharya, P. B., Jain, S. K., Nagpaul, S. R. (1994). Basic Abstract Algebra. Cambridge University Press.
Website and E-learning Source	**http://www.algebra.com/**

Department of Mathematics : Debraj Roy College
Title of the Course : Differential Equations
Paper Number : 1C2
Category CORE
Year 1
Credits 4
Course Code: MTHC2
Semester I
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical :0 Total :4

Prerequisites for the Course	Knowledge of ordinary differential equations of first order and second order and their General Solutions are essential. Knowledge of partial differential equations of first order is essential.
Objectives of the Course	The students will learn the governing mathematical formulations and their solutions of various physical problems.
Learning Outcome	After going through this course the students will be able to (i) Formulate the governing Mathematical equations of Physical Problems. (ii) (ii) Solve Differential Equations using various Mathematical tools
Course outline	**Unit I: Ordinary Differential Equations: Marks 15, L: 11, T: 4** Series solutions of second order linear differential equations, Legendre equation and Legendre polynomials, Bessel equation and Bessel functions, Systems of first-order linear differential equations. **Unit II: Partial Differential Equations of Second Order: Marks 15, L: 12, T: 4** Liner partial differential equations of second order with constant co-efficient, Characteristic curves of second order equations, Reduction to canonical forms, Separation of variables, Solution of non linear equations of the second order by Monge's method **Unit III: Laplace equation, Wave equations, Diffusion Equation: Marks 15, L: 12, T: 4** The occurrence of Laplace's equation in physics, Elementary solution of Laplace's equations, Boundary value problems, Solution of Laplace's equation by separation of variable, The occurrence

	of the wave equation in Physics, Elementary solutions of the one-dimensional Wave equation, Solution of the Wave equation by separation of variables The occurrence of the Diffusion equation in Physics, Elementary solutions of the Diffusion equation, Solution of the Diffusion equation by separation of variables. **Unit IV: Methods of Green's functions Marks 15, L: 10, T: 3** Green's function, Green's function for the Laplace's equation, Green's function for the wave equation, Green function for diffusion equation
Reference Books	1. Boyce, W. E., DiPrima, R. C. (2009), Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India 2. Piaggio, E. T. H. (1985), Differential Equations, CBS Publishers and Distributors 3. Bhamra, K. S. (2010), Partial Differential Equations, PHI Learning Pvt. Ltd. 4. Ayres, F (Jr.). (1972), Theory and Problems of Differential Equations, SI (Metric) edition, Schaum's outline series, Mc Graw Hill book Co.
Website and E-learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

Department of Mathematics : Debraj Roy College
Title of the Course : Real Analysis
Paper Number : 1C3
Category CORE
Year 1
Credits 4
Course Code: MTHC3
Semester I
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To build up a strong analytical foundation of basic Real Analysis.
Learning Outcome	After going through this course the students will be able to (i) Describe the properties of the Real numbers. (ii) (ii) Analyze the properties of

	advanced differentiation and Integration of real valued functions in one or multiple variables. (iii) (iii) Describe R as a matric space and identify its special metric properties.
Course Outline	**Unit I: Preliminaries: Marks: 20 L: 15 T: 5** Countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, convergence of sequence, continuity and uniform continuity. Metric spaces, compactness, completeness, Bolzano-Weierstrass theorem, Heine-Borel theorem; connectedness and continuity. **Unit II: Sequences of Functions: Marks: 13 L: 10 T: 3** Sequences and series of functions, Pointwise and uniform convergence, Monotonic functions, types of discontinuity, Absolute Convergence, functions of bounded variation, Continuous functions of bounded variation. **Unit III: Functions of Several Variables: Marks: 12 L: 9 T: 3** Directional derivatives, Continuity, total derivatives, Jacobian matrix, the chain rule and its matrix form, the mean value theorem for differentiable functions, sufficient condition for differentiability. **Unit IV: Riemann-Stieltjes Integral: Marks: 15 L: 11 T:4** Riemann-Stieltjes integrals, The R-S integral as a limit of sum, Classes of R-S integrable functions, Algebra of R-S integrable functions, Relation between Riemann and Riemann-Stieltjes integral.
Recommended Text	1. Bartle, R. G., Sherbert, D. R. (2011). Introduction to real analysis. Hoboken, NJ: Wiley. (For Unit 1 and 2) 2. Apostol, T.M. (2008). Mathematical Analysis. Narosa Publishing House. (For Unit 3 and 4). 3. Fitzpatrick, P. M., (2010). Advanced Calculus. Orient Black Swan. 4. Carothers, N. L. (2009). Real Analysis. S Chand. Reference Books 1. Rudin, W. (1964). Principles of mathematical analysis . New York: McGraw-hill. 2. Simmons, G. F. (1963). Introduction to Topology and Modern Analysis. McGraw Hill. 3. Kaczor, W. J., Nowak, M. T., Nowak, N. T. (2000). Problems in Mathematical Analysis: Integration. American Mathematical Soc. 4. Kumaresan, S. (2005). Topology of Metric

	Spaces. Narosa.
Website and Elearning Source	http:/www.mathforum.org, http:/opensource.org

Department of Mathematics : Debraj Roy College
Title of the Course : Complex Analysis
Paper Number : 2C1
Category CORE
Year 1
Credits 4
Course Code: MTHC4
Semester II
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	It is expected that the students will be exposed to an advanced course in Complex Analysis.
Learning Outcome	After going through this course, the students will be able to (i) Define various functions of Complex variables. (ii) (ii) Discuss the principles involved with Complex Integration. (iii) Obtain the conformal mappings of standard complex valued functions.
Course Outline	**Unit I : Functions of Complex variable: Marks 12 L: 9 T: 3** Functions of Complex variables, Mappings by exponential functions, limits, continuity, derivatives, Cauchy-Riemann equations, Analytic functions, Harmonic functions, Reflection principles, The exponential functions, logarithmic function, Branches and derivatives of logarithm, Complex exponents, Trigonometric functions, Hyperbolic functions, Inverse trigonometric functions. **Unit II : Integration of Complex functions: Marks 12 L: 9 T: 3** Basic properties of Complex Integration, Cauchy's Theorem, Morera's Theorem, Cauchy Integral formula, Laurent's series, The Maximum modulus principle, Schewarz lemma, Liouville's theorem. **Unit III: Series of Complex variables: Marks 12 L: 9 T**: Convergence of sequences, Convergence of series, Taylor series, Laurent Series, Absolute and uniform

	convergence of Power series, Uniqueness of series representation. **Unit IV : Calculus of Residues: Marks 12 L: 9 T: 3** Residue at a finite point, Residue at the point at infinity, Residue Theorem, Number of zeros and poles, Argument principle, Rouche's theorem, evaluation of Integrals, Application of residues, **Unit V : Conformal Mapping: Marks 12 L: 9 T: 3** Linear Transformation, Linear fractional transformation, mappings of upper half plane, The transformation w = sin z; mappings by z2 and Branches of z1/2 , square roots of polynomials, preservation of angles, scale factor, local inverses, harmonic conjugates, transformation of harmonic functions, Applications.
Recommended Text	1. Brown, J. W., Churchill, R. V. (2009). Complex variables and applications. Boston: McGrawHill Higher Education. 2. Ponnusamy, S. (2002). Foundations of functional analysis. CRC Press. 3. Apostol, T.M. (2008). Mathematical Analysis. Narosa Publishing House. Reference Books 1. Karunakaran, V. (2005). Complex analysis. Alpha Science Int'l Ltd. 2. Rudin, W. (2006). Real and complex analysis. Tata McGraw-Hill Education. 3. Hahn, L. S., Epstein, B. (1996). Classical complex analysis. Royal Society of Chemistry.
Website and E-learning Source	

Department of Mathematics : Debraj Roy College
Title of the Course : Linear Algebra
Paper Number : 2C2
Category CORE
Year 1
Credits 4
Course Code: MTHC5
Semester II
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To build up a foundation of Linear algebra
Learning outcome	After going through this course, student will able to (i) Give theoretical treatment to solve system of linear equations. **(ii)** (ii) Discuss basic properties of inner products spaces and operators.

Course Outline	**Unit I: Vector Spaces: Marks 10 L: 8, T: 2** Vector space, Subspaces, Linearly independent set, Basis and dimension, Sums and direct Sums **Unit II: Linear maps: Marks 10 L: 8, T: 2** Linear transformation and Operator, matrix representations of linear transformations, the rank and nullity theorem, Invertibility **Unit III: Eigenvalues and Eigenvectors: Marks 12 L: 9, T: 3** Eigenvalues and Eigenvectors, Invariant Subspaces, Polynomials applied to operators, Upper Triangular, Diagonal matrices **Unit IV: Inner Product Spaces and Operators: Marks 14 L: 10, T:4** Inner products, norms, orthogonal bases, linear functional and adjoints, Self adjoint and normal operators, spectral theorem, Normal operators on Real Inner product spaces, Positive operators, Isometries. **Unit V: Operators on Complex Vector Spaces: Marks 14 L:10, T:4** Generalized Eigenvectors, Characteristic Polynomial, Decomposition of an operator, minimal polynomial, Jordan form.
Recommended Text	1. Dummit, D. S., Foote, R. M. (2004). Abstract algebra. Hoboken: Wiley. 2. Saikia, P. K. (2014). Linear Algebra. Pearson Education India. 3. Axler. S. (1997). Linear Algebra Done Right. Springer.
Reference Books	1. Artin, M. (2015). Algebra. Pearson Ed. India. 2. Strang, G. (2005). Linear Algebra and its Applications. Cengage Learning. 3. Bhattacharya, P. B., Jain, S. K., Nagpaul, S. R. (1994). Basic abstract algebra. Cambridge University Press.
Website and E-learning Source	MIT OCW 18.06SC: Linear Algebra by Gilbert Strang. http://ocw.mit.edu/(Also available on Youtube)

Department of Mathematics : Debraj Roy College
Title of the Course : Numerical Analysis
Paper Number : 2C3
Category CORE
Year 1
Credits 4
Course Code: MTHC6

Semester II
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total   : 4

Objectives of the Course	To give a theoretical treatment to the numerical methods used to solve various problems of science and engineering
Learning outcome	After completing this course learners will be able to (i) Use and analyze various numerical methods in solving scientific problem (ii) Discuss various issues in a numerical techniques such as convergence and stability (iii) Fit polynomial and exponential function to a given set of data.
Course Outline	**Unit I: Floating point representation and Errors: Marks 5 L: 4, T:** Review of Taylor series, floating point representation, loss of significance **Unit II: Solution of system of equations: Marks 15 L: 11, T: 4** Doolittle and Crout's decomposition, Successive approximation by Gauss Jacobi, Gauss SeidaL Methods **Unit III: Numerical Integration: Marks 15 L: 11, T: 4**- Cotes formula, Gaussian quadrature Unit IV: Solution of Ordinary **Differential Equations: Marks 15 L: 11, T: 4** Stability and Convergence of numerical methods, Runge-Kutta method of second, third and fourth order, General explicit method, Adam-Bashforth, General implicit method, AdamMoultan, Milne-Simpson method. **Unit V: Curve Fitting: Marks 10 L: 8, T:2** General Least Square Method, Normal equations, Fitting of a polynomial (second and third degree), Fitting of exponential curves, Chebyshev polynomials.
Recommended Text	1. Kincaid, D., Cheney, W. (2002). Numerical Analysis: Mathematics of Scientific Computing. AMS. 2. Atkinson, K., Han, W. (2003). Elementary Numerical Analysis, John Wiley & Sons.
Reference Books	1. Hilderbrand, F.B. (1987). Elementary Numerical Analysis. Dover publications. 2. Conte, S.D. (1980). Elementary Numerical Analysis: Algorithmic approach. Tata McGraw Hills 3. Madhumangal, P. (2009). Numerical Analysis for Scientist and Engineers. Narosa Pub. House.
Website and E-learning Source	http://mathform.org.http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org.

Department of Mathematics : Debraj Roy College
Title of the Course : Functional Analysis
Paper Number : 3C1
Category CORE
Year 2

Credits 4
Course Code: MTHC7
Semester III
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	(i) To introduce a common mathematical framework for both algebraic and topological structures. (ii) To discuss generalization of classical analysis. To present some practical applicability of the theory developed.
Learning outcome	After going through this course, the students will be able to (i) Describe the interaction of algebraic and topological properties. (ii) (ii) Deal with problems related to the fundamental theorems like Hanh-Banach theorem, Closed Graph theorem, Open Mapping theorem and Uniform Boundedness Principle besides developing a sound basis of Banach and Hilbert spaces. (iii) (iii) Apply the theoretical aspects in solving problems of linear equations, differential equations, integral equations and some issues in Quantum Mechanics. Pre-requisites Basic knowledge of Linear Algebra and Metric Space.
Course outline	**Unit I: Normed and Banach spaces: Marks 15 L :12, T: 3** Definitions, examples and basic properties of Normed spaces and Banach spaces. Subspace, Compactness and finite dimension, Definitions, examples and basic properties of Bounded linear operators and functionals, Dual space. **Unit II: Fundamental theorems for Normed and Banach Spaces: Marks 15 L :11, T: 4** Open mapping theorem and its consequences, Closed graph theorem and its consequences, Uniform boundedness principal. Hanh-Banach Theorem and its consequences. Adjoint of bounded linear operator. **Unit III: Hilbert Spaces: Marks 15 L :11, T: 4**

	Definitions, example and basic properties of inner-product spaces and Hilbert spaces, Orthogonal Complements and direct sums, Orthogonal sets and sequences, Series related to Orthonormal sequences and sets, Total orthonormal sets. Legendre, Hermite and Laguerre polynomials, Riesz's representation theorem. Hilbert -Adjoint operator, Self Adjoint operator. **Unit IV: Some Applications: Marks 15 L :11, T: 4** Banach fixed point theorem and its applications to Linear Equations, Differential Equations and Integral Equations. Multiplication and Differential Operator in Quantum Mechanics.
Recommended Texts	1. Kreyszig, E. (1978). Introductory functional analysis with applications. New York: Wiley. 2. Choudhary, B., Nanda, S. (1989). Functional analysis with applications. Wiley. 3. Limaye, B. V. (2014). Functional Analysis. New Age International P Ltd.
Reference Books	1. Ponnusamy, S. (2002). Foundations of functional analysis. CRC Press. 2. Jain, P. K., Ahuja, O. P., Ahmed, K. (1995). Functional Analysis. New Age International (P) Limited.
Website and E-learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

Department of Mathematics : Debraj Roy College
Title of the Course : Graph Theory
Paper Number : 3C2
Category CORE
Year 2
Credits 4
Course Code: MTHC8
Semester III
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Prerequisites for the Course	Basic concepts of enumeration are essential
Objectives of the Course	Students will learn few interesting topics of Graph Theory as well as certain fascinating applications of various types of Graphs.
Learning outcome	After going through this course the students will be able to identify various types of graphs and their properties.
Course Outline	**Unit I : Graphs and Trees: Marks 15, L: 12, T: 4** Graph, Basic definitions, Isomorphism of graphs, Subgraphs, Walks, Paths, Circuits, Connected graphs, Disconnected graphs, Trees, Some properties of trees, Distance and centers in a tree, Rooted and binary trees, On counting trees, Spanning trees, Cut-sets, Some properties of a cut-set, Connectivity and Separability, Blocks. **Unit II : Operations On Graphs: Marks 15, L: 11, T: 4** Planar and nongraph, Matrix representation of graphs, Incidence matrix, Adjacency matrix, Graph matching, Graph coverings. **Unit III : Directed Graphs and Enumeration of Graphs: Marks 15, L: 11, T: 4** Definition of Directed graphs (digraph), Some types of digraphs, Digraphs and binary relations, Directed paths and connectedness, Acyclic digraphs and decyclization, Enumeration of graphs, Types of enumeration, Counting labeled trees, Counting unlabelled trees. **Unit IV : Graph Algorithms: Marks 15, L: 11, T: 3** Algorithms, Shortest-path algorithms, Transitive closure of a digraph, Activity network, Topological sorting, Critical path, Graphs in computer programming (basic concepts).
Recommended Text	1. Deo, N. (2017). Graph theory with applications to engineering and computer science. Courier Dover Publications. 2. Harary, F. (2001). Graph Theory. Narosa Publishing House. 3. West, D. B. (2002). Introduction to Graph Theory. Prentice Hall India.
Reference Books	1. Chartrand, G. (1984). Introductory Graph

	Theory. Dover Publications. 2. Bollobas, B. (1998). Modern Graph Theory. Springer. 3. Gross, J. L., Yellen, J. (2004). Handbook of Graph Theory. CRC Press. 4. Vasudev, C. (2006). Graph Theory with Applications. New Age Int. (P.). Ltd
Website and E-learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics

Department of Mathematics : Debraj Roy College
Title of the Course : Numerical Partial Differential Equation
Paper Number : 3C3
Category CORE
Year 2
Credits 4
Course Code: MTHC9
Semester III
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The objective of this course is to introduce various numerical techniques to solve partial differential equations
Learning outcome	After going through this course, the students will be able to (i) Describe various numerical techniques. (ii) (ii) Solve Partial Differential Equations numerically.
Course Outline	**Unit I: PDE and its classifications: Marks 15 L: 9, T: 3** Basics of PDE, classification of PDE (elliptic, parabolic and hyperbolic), Laplace equation, wave equation, convection-diffusion equation, initial values and boundary conditions, well posed problems. **Unit II: Elliptic PDE: Marks 15 L: 12, T: 4** General features of elliptic PDE, finite difference solutions of Laplace equation, consistency order and convergence, iterative methods of solution, ADI method, finite difference solution of Poisson equation, **Unit III: Parabolic PDE: Marks 15 L: 12, T: 4** General features of parabolic PDE, finite difference method, FTCS method, consistency, order, stability and convergence, BTCS and Crank-Nicolson method **Unit IV: Hyperbolic PDE: Marks 15 L: 12, T: 4** General features of hyperbolic PDE, finite difference method, FTCS method, Lax-Wendroff method, upwind method, BTCS

	method
Recommended Text Books	1. Hoffman, J. D., Frankel, S. (2001). Numerical methods for engineers and scientists. CRC Press. 2. Smith, G. D. (1985). Numerical Solutions to Partial Differential Equations, Oxford University Press.
Reference Book	1. Lapidus, L., Pinder, G. F. (2011). Numerical solution of partial differential equations in science and engineering. John Wiley & Sons. 2. Burden, R., Faires, D., Burden, A. M. (2015). Numerical Analysis. Cengage Learning.
Website and E-learning Source	https://www.wias-berlin.de/people/john/LEHRE/NUM_PDE_FUB/num_pde_fub.pdf, http://www.ehu.eus/aitor/irakas/fin/apuntes/pde.pdf

Department of Mathematics : Debraj Roy College
Title of the Course : Mathematical Methods
Paper Number : 4C1
Category CORE
Year 2
Credits 4
Course Code: MTHC10
Semester IV
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The objective of the course is to familiarize various essential procedure and tools which are frequently employed in analytical solution of problems arise in physical science. The technique of calculus of variations will be discussed for solving complex optimization problems in physical science, geometry and many other areas of interest in current trend
Learning outcome	After going through this course the students will be able to (i) Describe various mathematical methods to solve integral equations. (ii) Solve wide range of problems in physical sciences using calculus of variation.
Course Outline	**Unit I : Integral Equations: Marks 20 L:14, T:** 5 Definition of Integral Equation, Eigen values and Eigen functions: Reduction to a system of algebraic equations, Reduction of ordinary differential equations into integral equations. Fredholm integral equations with separable kernals, Method

	of successive approximations, Iterative scheme for Fredholm Integral equations of second kind, Conditions of Uniform convergence and uniqueness of series solution. Volterra Integral Equations of second kind, Resolvant kernel of Volterra equation and its results, Application of iterative scheme to Volterra integral equation of the second kind. Convolution type kernels. **Unit II: Fourier Transform: Marks 12 L:9, T: 4** Fourier Integral Transform, Properties of Fourier Transform, Fourier sine and cosine transform, Application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems. Evaluation of definite integrals. **Unit III: Calculus of Variation with one independent variable: Marks 14 L: 11, T: 3** Basic ideas of calculus of variation,Euler's equation with fixed boundary of the functional $$I[y(x) = \int_a^b f(x, y, y')dx$$ containing only the first order derivative of the only dependent variable with respect to one independent variable. Variational problems with functional having higher order derivatives of the only dependent variable, applications. **Unit IV : Calculus of Variation with Several variables: Marks 14 L: 11, T: 3** Variational problems with functional dependent on functions of several independent variables having first order derivatives, Variational problems in parametric form, variational problems with subsidiary condition (simple case only), Isoperimetric problems, Applications.
Recommended Text	1. Gupta, A. S. (1996). Calculus of variations with applications. PHI. 2. Parashar, B. P. (1994). Differential and Integral Equations. CBS Pub and Distributors. 3. Raisinghania, M. D. (2007). Integral equations and boundary value problems. S.Chand.
Reference Books	1. Mikhlin, S. G. (1960). Linear integral equations (translated from Russian). Hindustan Book Agency. 2. Hildebrand, F. B. (2012). Methods of applied mathematics. Courier Corporation.

	3. Spiegel, M. R. (1986). Theory and Problems of Laplace Transform. 4. Courant, R., Hilbert, D. (2008). Methods of Mathematical Physics: Partial Differential Equations. John Wiley & Sons.
Website and E-learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics

Department of Mathematics : Debraj Roy College
Title of the Course : Mathematical Modelling
Paper Number : 4C2
Category CORE
Year 2
Credits 4
Course Code: MTHC11
Semester IV
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course.	The objective of the course is to introduce the concept of representation of real world situations into Mathematical situations.
Learning Outcome	After going through this course the students will be able to (i) Make Mathematical Models of real life problems (ii) (ii) Solve real word problems through Mathematical Modelling
Course Outline	**Unit I: Introduction: Marks 15 L: 12, T: 3** The technique on Mathematical Modelling, Mathematical Modelling through Calculus, Mathematical Modelling through ordinary differential equation of first order, Linear Growth and Decay model, Nonlinear Growth and Decay model, Mathematical Modelling in dynamics through ordinary differential equation of first order. **Unit II: Mathematical Modelling through System of Differential Equations: Marks 15 L: 12, T: 3** Mathematical Modelling in population dynamics, Mathematical Modelling of Epidemics through system of differential equation of first order, Mathematical Modelling in Economics based on system of differential equation of first order,

	Mathematical Modelling in Medicine, Arms, Race Battles and International Trade in terms of ordinary differential equations. **Unit III: Mathematical Modelling through Difference Equations: Marks 15 L: 12, T: 3** Need of Mathematical Modelling through Difference Equations, Mathematical Modelling through Difference Equations in Economics, Finance, Population dynamics and genetics. **Unit IV: Mathematical Modelling through Graphs: Marks 15 L: 12, T: 3** Environment that can be modelled through Graphs, Mathematical Modelling in terms of Directed Graphs, Signed Graphs, weighted Diagraphs, Non-oriented Graphs.
Recommended Text	1. Kapur, J. N. (1988). Mathematical Modelling. New Age International. 2. Barnes, B., Fulford, G. R. (2008). Mathematical Modelling with Case Studies, CRC Press.
Reference Books	1. Bender, E. A. (2012). An introduction to mathematical modeling. Courier Corporation. 2. Meerschaert, M. M. (2013). Mathematical Modelling, Academic Press
Website and Elearning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics

Department of Mathematics : Debraj Roy College
Title of the Course : Measure Theory
Paper Number : 4C3
Category CORE
Year 2
Credits 4
Course Code: MTHC12
Semester IV
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The learners will be exposed to the Lebesgue Theory of Integration as an extension of the standard Riemann Theory.
Learning outcome	After going through this course, the students will be able to (i) Describe the properties of Measurable sets and functions.

	(ii) Integrate functions using Lebesgue Integration tools.
Course Outline	**Unit I : Measurable Sets: Marks 12 L: 9, T: 3** Outer measure, Lebesgue measure, measurable sets and their properties, Borel sets, Characterization of measurable sets, non-measurable sets. **Unit II :Measurable Functions: Marks 12 L: 9, T:** 3 Properties, Step functions, Characteristic functions, Simple functions, Continuous functions, Set of measure zero, Borel measurable function, Realization of non-negative measurable functions in terms of simple functions, Convergence in measure. **Unit III : Lebesgue Integrals: Marks 12 L: 9, T: 3** Riemann integrals, Lebesgue integration of a simple function, Bounded convergence theorem, Fatou's lemma, Monotonic Convergence Theorem, integrable functions, General Lebesgue Integral, Dominated convergence theorem. **Unit IV: L^p -Space: Marks 12 L: 9, T: 3** The L^p space, Holder, Minkowski's inequalities, summable sequence, essential supremum, Completeness ofL^p Lp space, Bounded linear functional on L^p spaces. **Unit V: Probability Measure: Marks 12 L: 9, T: 3** Measurable space, measure space, finite and sigma-finite measures, Axiomatic definition of Probability, definition of Random Variable, Measure induced by a measurable function, definition of Probability distribution and distribution function, properties of distribution function and classification of distributions, Expectation as Lebesgue Integrals.
Recommended Text	1. Berra, G. D. (2014). Measure Theory and Integration. Wiley Eastern LTD. 2. Royden, H. L. (2002). Real Analysis. Mc-Millan 3. Feller, W. (1966). An Introduction to Probability Theory and its Applications.
Reference Books	1. Rudin, W. (1998). Principles of Mathematical Analysis. McGraw Hill. 2. Jain, P K., Gupta, V. P., Jain, P. (2010). Lebesgue Measure and Integration. New Age International Publisher.

Website and E-learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics

Department of Mathematics : Debraj Roy College
Title of the Course : Tensor and Classical Mechanics
Paper Number : 1D1
Category : DSE
Year 1
Credits 4
Course Code: MTHD1
Semester I
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	On completion of the course, the students will be able to build a strong foundation for Tensor Analysis for its application • in Continuum Mechanics, Fluid Dynamics, MHD, Classical Mechanics etc. learn the mathematical formulations of various mechanical problems•
Course outline	**UNIT –1 : Cartesian, Rectilinear and Curvilinear coordinate Systems: Marks-10** Scalars, vectors and Tensors, Index Notations, Kronecker delta, Permutation symbols, Cartesian coordinate system, Rectlinear coordinate systems, Fundamental and reciprocal basis, derivation of formula for determining reciprocal basis, curvilinear coordinate systems, basis and reciprocal basis in curvilinear coordinate systems, Examples and Exercise. **UNIT–2 : General Tensors and the metric tensor: Marks-10** General tensor, the metric tensor, the permutation tensor, Tensor algebra, the quotient rule, physical components of a tensor, scalar product, vector product and scalar triple product in various forms. Examples and Exercise. **UNIT: 3 Christoffel symbols and Covariant differentiation: Marks 10**

	Partial derivative of a vector, Christoffel symbols, Christoffel symbols in terms of derivative of the metric tensors, Christoffel symbols in orthogonal coordinate systems, covariant derivative of covariant and contravariant components of vectors and second order tensors, covariant derivative of scalars, laws of covariant differentiation, Ricci's theorem, Gradient of a scalar, divergence and curl of vector, Laplacian of a scalar, Examples and Exercise. **Unit 4: Lagrangian approach in Mechanics: Marks 10** Constrained motion and classifications of constrains of motion, degrees of freedom, generalized coordinates, generalized velocities, total Kinetic energy of a system of particles in terms of generalized velocity, generalized momenta and generalized force. Lagrange's equation of motion using D'Alemberts principle. **Unit 5: Hamilton's Principle Marks 10** Euler's Lagrange differential equation and Brachistochrone problem, problem of shortest distance between two points on plane. Introduction of Hamilton's Principle of least action, Derivation of Lagrange's form of equation of motion using Hamilton's principle of least action, conservation principles and symmetry properties. **Unit-6: Hamiltonian Formulation Marks 10** Hamilton's canonical equation of motion, canonical variables, cyclic co-ordinates, Canonical transformations and generating functions. Introduction of Lagrangian bracket and Poissons's bracket and their properties and applications, Introduction to Hamilton-Jacobi theory and applications.
Recommended Text	1. Young, E. C. (2017). Vector and tensor analysis. CRC Press. 2. Aris, R. (2012). Vectors, tensors and the basic equations of fluid mechanics. Courier Corporation. 3. H. Goldstein, Classical Mechanics, Addision Wesley Publishing Company, INC. USA. 4. Lagrangian and Hamiltonian Mechanics by M.G. Calkin, World Scientific, Singapore. 1996
Reference Books	1. Sharma, B. R. (2017). Tensor Analysis: A Primer.

	Mahaveer publications 2.Calkin, M. G., Lagrangian and Hamiltonian Mechanics, World Scientific, Singapore. 1996 3.Lebedev and Cloud, Tensor Analysis, World Scientific Publishing Co Pte Ltd 4.Gupta, kumar and Sharma, Classical Mechanics, Pragati Prakashan
Website and Elearning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org,

Department of Mathematics : Debraj Roy College
Title of the Course : Combinatorics and Probability
Paper Number : 1D2
Category : DSE
Year 1
Credits 4
Course Code: MTHD2
Semester I
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	This course will introduce the theory of enumeration and probability.
Learning Outcome	After going through this course, learners will be able to (i) Use techniques of enumeration in real life problems **(ii)** Model the real life situations using probability theory.
Course Outline	**UNIT I: Combinatorics: Marks: 25, L: 20, T: 5** Counting principles, multinomial theorem, set partitions and Stirling numbers of the second kind, permutations and Stirling numbers of the first kind, infinite matrices, inversion of sequences, probability generating functions, generating functions, evaluating sums, the exponential formula **UNIT II: Probability: Marks: 20, L: 15, T: 5** Axiomatic definition of probability, probability spaces, probability measures on countable and uncountable spaces, conditional probability, independence; Random variables, distribution

	functions, probability mass and density functions, functions of random variables, standard univariate discrete and continuous distributions and their properties; **Unit III: Moments and Joint Distribution Marks 15, L: 10, T: 5** Mathematical expectations, moments, moment generating functions, characteristic functions, inequalities; Random vectors, joint, marginal and conditional distributions, conditional expectations, independence, covariance, correlation, standard multivariate distributions
Recommended Text	1. Stanley, R.P. (2011). Enumerative Combinatorics. Cambridge Univ Press. 2. Ross, S. M. (2002). A first course in probability. Pearson Education India. 3. Rohatgi, V. K., Saleh, A. K. Md. E. (2001). An Introduction to Probability and Statistics. Wiley.
Reference Books	1. Berge, C. (1971). Principles of combinatorics. New York, 176. 2. Aigner, M. (2007). A course in Enumeration . Springer Science & Business Media. 3. Ross, S. M. (2007). Introduction to Probability Models. Elsevier.
Website and E-learning Source	http://mathforum.org , http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

Department of Mathematics : Debraj Roy College
Title of the Course : Magnetohydrodynamics
Paper Number : 2D1
Category : DSE
Year 1
Credits 4
Course Code: MTHD3
Semester II
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	Starting with electric and Magnetic properties of conducting fluid, learners will get idea how magnetic field may play dominant role in governing flow of conducting liquid. Discussion of fundamental aspects of conducting flow in presence of Magnetic field. The 1 D cases of steady

	and unsteady flow in linear regime are considered in this course.
Learning Outcome	After going through this course students will be able to (i) Describe electro-magnetic equations (ii) Solve linear flow problems in MHD
Course outline	**Unit I:Fundamental of Electrodynamics and MHD approximations: Marks: 16, L: 12, T:4** The electrical properties of Fluid, electric and magnetic field, Lorentz force , action at a distance, the low frequency approximations, relative and absolute quantities, energetic aspects of MHD, equation of continuity of charge, equation of motion of conducting fluid, Pointing theorem. **Unit II: The Kinematics in MHD : Marks: 16, L: 12, T:4** The Maxwell electromagnetic equations, the magnetic induction equation, the analogy with vorticity, diffusion and convection of magnetic field , Magnetic Reynold number, the dynamo problem, Alfven's theorem, the Ferraro's law of isorotations, the two dimensional kinematic problem with flow in the direction of no variation, the two dimensional kinematic problem with field in the direction of no variation, the two dimensional kinematic problem with current in the direction of no variation. **Unit III: The magnetic force and its effects: Marks: 12, L: 9, T: 4** The magnetic force and the inertia force , magnetic stress , principal directions and stress, Magnetohydrostatic, The linear pinch confinement scheme, the force free fields, the magnetic field in moving fluid invalidation of Kelvin's theorem on vorticity, the case of irrotational force per unit mass. **Unit IV: Boundary Conditions on Magnetic field and 1-D linear flow problems in MHD: Marks 16, L: 12, T: 4** Boundary conditions for magnetic field, the steady Hartmaan Flow problems, Poiseuille type flow, Couette type of Flow, linear Alfven waves, MHD Rayleigh problem.
Recommended Text	1. Shercliff, J. A. (1965). Textbook of Magnetohydrodynamics. Pergamon Press, New York. 2. Davidson, P. A. (2002). An introduction to

	Magnetohydrodynamics.
Reference Books	1. David, J. G. (2015). Introduction to Electrodynamics. Introduction to Magnetohydrodynamics. Pearson. 2. Chorlton, F. (1967). Textbook of fluid dynamics , Van Nostrand. 3. Hughes, W., Young, F. J. (1966). Electro-magneti-hydrodynamics, John Willey and Sons. 4. Cowling, T. J. (1976). Magnetohydrodynamics. Crane Russak & Co.
Website and E-learning Source	http://mathforum.org , http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

Department of Mathematics : Debraj Roy College
Title of the Course : Fuzzy Set Theory
Paper Number : 2D2
Category : DSE
Year 1
Credits 4
Course Code: MTHD4
Semester II
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The objective of the course is to introduce classifications and modelling of Uncertainty
Learning Outcomes	After going through this course the students will be able to (i) Explain uncertainty using fuzzy set theory (ii) Gauge Uncertainty of fuzzy set (iii) Apply fuzzy set theory in different types real world problems under uncertainty
Course Outline	**Unit I: Basic of Fuzzy Sets: Marks: 12, L: 9, T: 3** Uncertainty, Taxonomy of Uncertainty, Motivation, Concepts of crispness and fuzziness, Fuzzy set and its representation, cut, convex fuzzy set, basic operations on fuzzy sets, types of fuzzy sets, extension principle, t-norm, t-conorms and their properties. **Unit II: Fuzzy Arithmetic and Method of**

	Construction of Membership Function: Marks: 12, L: 9, T: 3 Fuzzy Numbers Types of Fuzzy numbers, Interval Arithmetic, Arithmetic operations on fuzzy numbers, membership function formulation. **Unit III: Fuzzy Relations: Marks: 12, L: 9, T: 3** Fuzzy relation, binary fuzzy relations, union and intersection of fuzzy relations, projection and cylindrical extensions, fuzzy equivalence relation, Fuzzy compatibility relations, Fuzzy ordering relations, compositions of fuzzy relations and their properties. **Unit IV: Fuzzy logic and Fuzzy System: Marks: 12, L: 9, T: 3** Defuzzification, classic and fuzzy logic, approximate reasoning, linguistic hedges, fuzzy inference, fuzzy rule based system. **Unit-V: Uncertainty measure and Applications of Fuzzy sets: Marks: 12, L: 9, T: 3** Uncertainty based information, non-specificity of fuzzy set, fuzziness of fuzzy sets, Applications of fuzzy sets in decision making and other real world problems.
Recommended Text	1. Klir, G. J., Yuan, B. (1995). Fuzzy sets and Fuzzy logic: theory and applications. New Jersey: Prentice Hall PTR. 2. Zimmermann, H. J. (2011). Fuzzy set theory and its applications. Springer Science & Business Media.
Reference Books	1. Ross, T. J. (2005). Fuzzy logic with engineering applications. John Wiley & Sons. 2. Pedrycz, W., Gomide, F. (1998). An introduction to fuzzy sets: analysis and design. MIT Press.
Website and Elearning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.algebra.com

Department of Mathematics : Debraj Roy College
Title of the Course : Nonlinear Dynamical Systems and Chaos
Paper Number : 2D3
Category : DSE
Year 1
Credits 4

Course Code: MTHD5
Semester II
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The objective of this course is to introduce (i) Flow on a line and bifurcation in one dimensional flows (ii) Classification of linear and nonlinear system, limit cycles (iii) One dimensional maps, fractals and chaos
Learning Outcome	After going through this course, students will be able to (i) Find the fixed points and their stability in nonlinear dynamical systems (ii) Apply the methods discussed in this topic to draw interpretations of a dynamical system modeled in terms of ordinary differential equations / difference equations without solving the problems exactly.
Course Outline	**Unit I: One Dimensional Flows and Bifurcations: Marks: 12, L:9, T:3 Contact hrs: 12 (Theory: 9, Tutorial: 3), Marks: 12** Introduction, Fixed points and Stability, Population Growth, Linear Stability Analysis, Existence and Uniqueness, Impossibility of oscillations, Saddle-node bifurcation, Transcritical bifurcation, Pitchfork bifurcation, Imperfect bifurcations, Flow on the circle. **Unit II: Two Dimensional Flows and Bifurcations: Marks: 24, L:18, T:6** Linear Systems: Definition, examples and classification of linear systems, Phase planes: Introduction, phase portraits, conservative systems, Reversible systems, Index theory, Limit cycles: Introduction and examples, Ruling out closed orbits, Liapunov Functions, Poincare-Bendixson, theorem, Lienard Systems, Relaxation Oscillators, Weakly non-linear oscillators, Saddle-node bifurcation, Transcritical bifurcation, Pitchfork bifurcation, Hopf bifurcation, **Unit III: Chaos: Marks: 24, L:18, T:6** Lorenz Equations: Introduction, Simple properties of the Lorenz equation, Definitions of chaos, attractors and strange attractors, One dimensional maps: Introduction, Fixed points and Cobwebs,

	Numeric and analysis of Logistic map, Renormalization, Fractals: Countable and uncountable sets, Cantor set and its fractal property, Dimensions of self similar fractals, Box Dimension, The von Koch curve, Strange attractors, The Baker's map B.
Recommended Text	1. Strogatz, S. H. (2018). Nonlinear Dynamics and Chaos with Student Solutions Manual: With Applications to Physics, Biology, Chemistry, and Engineering. CRC Press. 2. Kaplan, D., Glass, L. (2012). Understanding nonlinear dynamics. Springer Science & Business Media.
Reference Books	1. Thompson, J. M. T., Thompson, M., Stewart, H. B. (2002). Nonlinear dynamics and chaos. John Wiley & Sons. 2. Devaney, R., (2003) An Introduction to Chaotic dynamical systems., West-view Press.
Website and E-learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.algebra.com

Department of Mathematics : Debraj Roy College
Title of the Course : Operations Research
Paper Number : 2D4
Category : DSE
Year 1
Credits 4
Course Code: MTHD6
Semester II
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To build up a strong analytical foundation of the Operations Research methods and Theory
Learning Outcome	After going through this course the students will be able to 1. Model and solve non-linear programming problems. 2. Solve the minimum and maximum tree problems. 3. Apply the OR tools in real time Industry oriented problems.
Course Outline	**Unit I: OR Fundamentals: Marks: 12, T: 9, L:3**

	Introduction to Operations Research: Basics definition, scope, objectives, phases, models and limitations of Operations Research. Linear Programming Problem Formulation of LPP, Graphical solution of LPP. Simplex Method, Artificial variables, big-M method, two-phase method, degeneracy and unbound solutions, sensitivity analysis-graphical approach. **Unit II: Non-linear Programming: Marks: 12, T: 9, L:3** Non-linear Programming: single variable optimization, sequential search techniques, Fibonacci search, convex functions, multi-variable optimizations without constraints: the method of steepest ascent, Newton-Raphson method, multi-variable optimizations with constraints: Lagrange multipliers, Newton- Raphson method, Penalty function,Khun-Tucker conditions. **Unit III: Network Analysis: Marks: 12, T: 9, L:3** Networks, Minimum-span problems, Shortest route problems, Maximal flow problems, PERT/CPM. Critical path computations for PERT, Construction of Time schedules. LPP formulations for PERT. **Unit IV: Deterministic Inventory Modelling: Marks: 12, T: 9, L:3** Inventory models, fixed order quantity models, fixed order period models, single period models, storage limitations. **Unit V: Game Theory: Marks: 12, T: 9, L:3** Game Theory. Competitive games, rectangular games, saddle point, minimax (maximin) methods of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point mixed strategy for 2 X 2 games.
Recommended Text	1. Taha, H. A. (2007). Operations Research: an introduction. Pearson Education, 2007. 2. Bronson, R., Naadimuthu, G. (1997). Operations Research Schuam's outline
Reference Books	1. Sharma, J. K. (2007). Operations Research Theory & Applications. Macmillan India Ltd. 2. Raju, N.V.S. (2002). Operations Research. HI-TECH. 3. Swarup, K., Gupta, P. K., Mohan, M. (2014). Operation Research.Sharma, S. Chand & Sons.

Website and Elearning Source	http:/www.mathforum.org, http:/opensource.org

Title of the Course : Mathematical Biology
Paper Number : 2D5
Category : DSE
Year 1
Credits 4
Course Code: MTHD7
Semester II
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To introduce certain mathematical tools like linear algebra, probability, Difference equations and Differential equations in modeling some aspects of Biological Systems.
Learner Outcome	After going through this course, students will be able to (i) Relate mathematical notions with biological phenomena (ii) Solve simple biological problems using discussed models.
Course Outline	**Unit I : Modeling Population Dynamics : Marks: 15, L: 12, T:3** Dynamic modeling with difference equations ; The Malthusian Model, Nonlinear Models, Analyzing Nonlnear Models, Variations on the Logistic Model, Comments on Discrete and Continuous Models. Linear Models of Structured Populations; Linear models and Matrix Algebra, Projection Matrices for Structured Models. Reproduction and the drive for survival ; The Darwinian Model of Evolution, Cells,replication of Living Systems, Population Growth and its Limitations, The Exponential Model for Growth and Decay. Age Dependent Population Structures; Aging and Death, The Age Structure of Populations, Predicting the Age Structure of a Population. **Unit II : Modeling Molecular Evolution: Marks: 15, L: 11 T:4** Background on DNA, An Introduction to Probability, Conditional Probabilities, Matrix Models for base substitution, Phylogenetic Distances, Phylogenetic Trees. **Unit III Genetics: Marks: 15, L: 11, T:4** Asexual Cell Reproduction, Sexual Reproduction, Classical Genetics, A Final Look at Darwinian Evolution, The Hardy-Weinberg Principle, The Fixation of a Beneficial Mutation. Mendelian

	genetics, Probability distribution in Genetics, Linkage, Gene Frequency in populations. **Unit IV Modeling Disease Spread: Marks: 15, L: 11, T:4** Infectious Disease Modeling; Elementary Epidemic Models, Threshold Values and Critical Parameters, Variations on a Theme, Multiple Population and Differentiated Infectivity. A Mathematical Approach to HIV and AIDS ; Viruses, The Immune System, HIV and AIDS, An HIV Infection Model, A Model for a Mutating AIDS, Predicting the Onset of AIDS,
Recommended Texts	1. Allman, E. A., Rhodes, J. A. (2004). Mathematical Models in Biology: An Introduction. Cambridge University Press. 2. Edward K. Y., Ronald W. S., James, V. H., (2011). An Introduction to the Mathematics of Biology: With Computer Algrbra Models. Springer.
Reference Books	1. Barnes, B., Fulford, G. R. (2008). Mathematical Modelling with Case Studies, CRC Press. 2. Chou. C. S., Friedman, A. (2016). Introduction to Mathematical Biology. Springer. 3. Keshet, L.E. (1988). Mathematical Models in Biology, Random House New York.

Department of Mathematics : Debraj Roy College
Title of the Course : Advanced Algebra
Paper Number : 3D1
Category : DSE
Year 2
Credits 4
Course Code: MTHD8
Semester III
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To introduce to the students some advanced aspects of Abstract Algebra
Learner Outcome	Students will be able to relate algebraic properties with geometric properties
Course Outline	**Unit -1 Marks : 15, L: 10, T: 3** Solvable and Nilpotent Groups. Normal and Subnormal series **Unit -2 Marks : 15, L: 11, T: 4**

	Commutative Rings and Modules ; Chain conditions, Prime and Primary Ideals, Noetherian rings and Modules **Unit-3 Marks : 15, L: 12, T: 4** Field, Polynomial ring over field, Field Extension, Algebraic and Transcendental elements, Characterization of Extensions, Finite Extensions, Properties of Algebraic Extensions. **Unit 4 Marks : 15, L: 12, T: 4** Galois Theory; Automorphism groups and fixed fields, Fundamental theorem of Galois Theory, Fundamental theorem of Algebra, Polynomial solvable by radicals, Ruler and Compass Construction.
Recommended Text	1. Gallian, J. A. (2013). Contemporary Abstract Algebra, New Age International. 2. Hungerford, T. W. (1974). Algebra. Springer-Verlag. New York. 3. Bhattacharya, P. B., Jain, S. K., Nagpaul, S. R. (1994). Basic Abstract Algebra. Cambridge University Press.
Reference Books	1. Herstein, I. N. (1975). Topics in Algebra Wiley. Eastern Limited. 2. Dummit, D. S., Foote, R. M. (2004). Abstract Algebra. Hoboken: Wiley.
Website and Elearning Source	www.algebra.org

Department of Mathematics : Debraj Roy College
Title of the Course : Dempster-Shafer Theory of Evidence
Paper Number : 3D2
Category : DSE
Year 2
Credits 4
Course Code: MTHD9
Semester III
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The objective of the course is to introduce taxonomy, representation and modeling of Uncertainty
Learning Outcome	After going through this course the students will be able to (i) Design and measure uncertainty using Dampster-Shafer theory (ii) Solve different types of real world

	problems under uncertainty
Course Outline	**Unit I: Dempster Shafer Theory: Marks: 15 L: 12, T: 4** Uncertainty, Types of Uncertainties, Sources and Nature of Uncertainty, Concept of Dempster-Shafer theory (DST), Basic Probability Assignment (BPA) and Its properties, Belief and Plausibility measure, Properties of Belief and Plausibility measures, Relation between Belief and Plausibility measures, Cumulative Belief and Plausibility measures, Focal Elements, Dempster-Shafer Structure (DSS), Necessity, Possibility measures and their Properties . **Unit II: Combination of Evidence in DST and Arithmetic of DSSs: Marks: 15 L: 11, T: 4** Dempster's Rule of combination of BPA, Yager's rule of combination, Inagaki's Rule of combination, Zhand's rule of combination, Combination of Evidence with Different Weighting Factors, Other Modified rule of combinations, Arithmetic of DSSs. **Unit III: Methods of Construction of BPA and Uncertainty Based Information: Marks: 15 L: 11, T: 4** Approaches to construct BPA, Uncertainty based information, Non-specificity, Entropy like measure, Strife, Fuzziness in DST, Probability-Possibility transformations. **Unit IV: Applications of DST: Marks: 15 L: 11, T: 3** Applications of DST in decision making and other real world problems.
Recommended Text	1. Shafer, G. (1976). A Mathematical Theory of Evidence, Priceton University Press. 2. Ayyub, B. M., Klir, G. J. (2006). Uncertainty modeling and analysis in engineering and the sciences. Chapman and Hall/CRC.
Reference Books	1. Yager R. R., Liu, L. (2008). Classical works of the Dempster-Shafer theory of belief functions, Springer. 2. Yager, R., Kacprzyk J., Fedrizzi, M. (1994). Advances in the Dempster-Shafer theory of evidence. Wiley and Sons.
Website and Elearning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org, www.algebra.com

Department of Mathematics : Debraj Roy College
Title of the Course : Fluid Dynamics
Paper Number : 3D3
Category : DSE
Year 2
Credits 4
Course Code: MTHD10
Semester III
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The objective of this course is to introduce (iv) Fundamental aspects of fluid flow behaviours. (v) Dynamics of viscous fluid flows and governing equations of motion.
Learning Outcome	After going through this course, students will be able to (i) Describe stress-strain relationship of Newtonian fluids. **(ii)** Derive some exact solutions of Navier-Stokes equations under different geometries.
Course Outline	**Unit I: Kinematics of Fluids in motion & Stress and Strain Analysis: Marks: 20, L: 15, T:5** Methods of describing fluid motion, material, local and convective derivatives, path lines, stream lines, vortex lines, strain and its types, small deformation theory, stress vector and stress tensor, various stresses, constitutive equations, Reynolds transport formula, conservation laws and mathematical forms in various fluid motions (steady and unsteady, compressible and incompressible, **Unit II: Two and Three Dimensional Inviscid Fluid Flows: Marks: 14, L: 10, T:4** Complex potential, Sources, sinks, doublets, images with respect to plane and circle, MilneThomson circle theorem, Blasius theorem, motion past a circular cylinder, axi-symmetric flows, - **Unit III: Navier-Stokes Equations and its Exact Solutions: Marks: 14, L: 11, T:3** Navier-Stokes equations, rate of change of circulation, diffusion of vorticity, vorticity equation and energy dissipation due to viscosity, exact solutions of Navier-Stokes equations: Couette flow, Poiseuille flow, Hagen-Poiesuille flow

	through a pipe, flow through annular region, Stokes first problem. **Unit IV: Boundary Layer Theory: Marks: 12, L: 9, T: 3** Laminar boundary layer, two-dimensional boundary layer equations, Blasius equation, boundary layer parameters, separation of boundary layer, momentum and energy integral equation.
Recommended Text	1. Chatterjee, R. (2015). Mathematical Theory of Continuum Mechanics. Narosa Publishing House. 2. Schlichting, H., Gersten, K. (2016). Boundary-layer theory. Springer. 3. Chorlton, F. (2004). Textbook of fluid dynamics. CBS Publisher.
Reference Books	1. Spencer, A. J. M. (2004). Continuum Mechanics. Dover Publications. 2. Raisinghania, M. D. (2003). Fluid Dynamics. S. Chand Publications. 3. Lamb, S. R. (1945). Hydrodynamics. Dover Publications. 4. Ramsay, A. S. (1913). Hydrodynamics (A Treatise on Hydromechanics). G. Bell and Sons, ltd. 5. Kundu, P.K. Cohen, I. M., Dowling, D. R. (2011). Fluid Mechanics. Academic Press. 6. Thomson, L. M. M. (2011). Theoretical Hydrodynamics. Dover Publications
Website and E learning Source	https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unified-engineering-i-ii-iii-iv-fall2005-spring-2006/fluid-mechanics/

Title of the Course : Network Science
Paper Number : 3D4
Category : DSE
Year 2
Credits 4
Course Code: MTHD11
Semester III
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Prerequisites for the Course	Basic of Graph Theory is required.
Objectives of the Course	Students will learn the application of graph Theory and games on networks
Learning Outcome	After going through this course, learners will be

	able to (i) Use graph and game theoretic tools in networks (ii) Analyse and differentiate the networks critically.
Course Outline	**Unit I: Mathematics of Networks: Marks: 15 L: 12, T: 4** Networks and their representation, weighted network, directed network, bipartite network, hypergraphs. **Unit II: Measures and Metrics: Marks: 15 L: 11, T: 3** Shortest path, degree distribution, Power laws, Centrality, Reciprocity, Similarity, Homophily and Assortative mixing. **Unit III: Network Models: Marks: 15 L: 11, T: 4** Random graphs, Giant component, Small-world, Scale-free. Four Broad Classes of networks: technological, information, social and biological. **Unit IV: Games on Networks: Marks: 15 L: 11, T: 4** General Model, Discussion of two assumptions, Strategic network formation, pairwise stability, efficient networks
Recommended Text	1. Newman, M. E. J. (2018). Networks: An Introduction. Oxford University Press. 2. Barabasi, A. L. (2016). Network Science, Cambridge University Press.(www.networksciencebook.com) 3. Goel, S. (2009). Connections, Princeton University Press.
Reference Books	1. Newman, M. (2010). The structure and dynamics of networks. New Age International Pvt Ltd; First edition. 2. Jacksin, M. O. (2008). Social and Economic Networks, Princeton University Press. 3. Wasserman, S., Faus, K. (1999). Social Network Analysis. Cambridge University Press.
Website and E-learning Source	http://www.networksciencebook.com

Title of the Course : Algebraic Graph Theory
Paper Number : 4D1
Category : DSE
Year 2
Credits 4
Course Code: MTHD12
Semester IV
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Prerequisites for the course	Basics of Graph Theory and Linear Algebra are required.
Course Objectives of the Course	This course helps to understand and evaluate the algebraic aspects related to graphs
Learning Outcome	After going through this course, students will be able to (i) Represent graphs using Matrics (ii) Evaluate and discuss various spectra related to graphs.
Course Outline	**Unit I: Reviews: Marks: 10, L: 7, T: 3** Basics of Graph theory and Linear Algebra, Matrix Representations of a graph: Adjacency matrix and Incidence matrix. **Unit II: Spectrum of a graph: Marks: 20, L: 16, T: 4** Eigenvalues and Walks, Eigenvalues and Labeling of graphs, Lower and Upper Bounds for the Eigenvalues, Regular and Line graphs. **Unit III: Laplacian Spectrum: Marks: 20, L: 16, T: 4** Laplacian of a graph, Laplacian Eigenvalues, Tree number, The Max-Cut Problem. Seidel matrix and Signless Laplacian matrix. **Unit IV: Determinant Expansion: Marks: 10, L: 6, T: 4** Determinant of adjacency matrix, coefficients of characteristic polynomial, Vertex partition and spectrum.
Recommended Text	1. Biggs, N. (1974). Algebraic Graph Theory. Cambridge University Press. 2. Wilson, R. J., Beineke, I. W. (2004). Topics in Algebraic Graph Theory. Cambridge University Press.
Reference Books	1. Knauer, U. (2011). Algebraic Graph Theory. Hubert & Co., Germany. 2. Godsil, C., Royle, G. (2001). Algebraic Graph Theory. Springer Verlag Newyork.
Website and E-learning Source	http://www.graphtheory.com/

Title of the Course : Computational Fluid Dynamics
Paper Number : 4D2
Category : DSE
Year 2
Credits 4
Course Code: MTHD13
Semester IV
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	Introduction of various numerical techniques and tools to solve fluid flow problems and some practicals on it
Learner Outcome	After going through this course students will be able to (i) Describe various numerical methods used in CFD (ii) Solve fluid flow problems using CFD techniques and tools
Course Outline	**Section A: Unit I: Basics of CFD and Discretization: Marks:15, L: 10, T: 4** CFD, governing equations of fluid dynamics, finite control volume, infinitesimal fluid element, substantial derivative, governing equations of fluid dynamics, boundary conditions, forms suitable for CFD, classifications of PDE, Discretization techniques, explicit and implicit approaches, errors and stability, general transformation equations, stretched grid, boundary fitted co-ordinate systems. **Unit II: CFD Techniques: Marks:15, L: 10, T: 3** Lax-Wen and MacCormack's technique, Relaxation technique, ADI Technique, pressure correction technique. **Unit III: Solutions using Numerical techniques: Marks:15, L: 10, T: 3** Numerical solution of Quasi-One Dimensional Nozzle Flows, Incompressible Couette flow: Numerical Solutions using Implicit Crank-Nicholson technique, Numerical Solution by solving Complete-Navier-Stokes equation. Section B: Practical: Marks: 15, L: 15, P:10Development of code and execution in FORTRAN/C/C++ for various flow problems using Crank-Nicholson technique.
Recommended Text	1. Anderson. J. D. (1995). Computational Fluid Dynamics the Basics with Applications. Mc-Graw Hill. 2. Chung, T. J. (2010). Computational fluid dynamics. Cambridge university press.
Reference Books.	1. Sengupta, T. K. (2004). Fundamentals of computational fluid dynamics. Hyderabad (India): University Press
Website and E learning Source	http://web.engr.uky.edu/~acfd/me691-lctr-nts.p

Title of the Course : Game Theory
Paper Number : 4D3
Category : DSE
Year 2
Credits 4
Course Code: MTHD14
Semester IV
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To build up a strong analytical foundation of Game Theory
Learning Outcome	After going through this course the students will be able to (i) Model the rational behavior of agents engaged in conflicts. **(ii)** Distinguish between the cooperative and non-cooperative approaches of Games. **(iii)** Apply the models of Game Theory in socio-economic problems.
Course Outline	**Unit I: Game Theory Fundamentals: Marks: 12, L: 9, T:3** Historical background; Zero sum games; non-zero sum games; extensive form games;Cooperative games; Bargaining games; Cooperative versus non-cooperative games; **Unit II: Two-person Zero-sum Games: Marks: 12, L: 9, T:3** Saddle point; Minimax and maximin strategies; Solving 2xn and mx2 games; Dominance; Mixed strategy; Linear Programing Methods to solve a two person zero sum game. **Unit III: Two-person Non-Zero-sum Games: Marks: 12, L: 9, T:3** Basic Definitions; Nash equilibrium;Pure and mixed strategies in Nash equilibrium. **Unit IV: Extensive Form Games: Marks: 12, L: 9, T:3** The Extensive Form; The Strategic Form; Backward induction and subgame perfection;Perfect Bayesian equilibrium. **Unit V: Cooperative Game Theory: Marks: 12, L: 9, T:3** Cooperative Games with Transferable Utility; The Core; The Shapley value;
Recommended Text	1. Narahari, Y. (2014). Game Theory and

	Mechanism Design. World Scientific. 2. Chakravarty, S.R., Mitra, M., Sarkar, P. (2015). A Course on Cooperative GameTheory. Cambrige University Press.
Reference Books	1. Peter, H. (2008). Game Theory A Multi-leveled Approach. Springer.
Website and E-learning Source	http:/www.mathforum.org, http:/opensource.org

Department of Mathematics : Debraj Roy College
Title of the Course : Topology
Paper Number : 4D4
Category : DSE
Year 2
Credits 4
Course Code: MTHD15
Semester IV
Instructional Hours (Per week)

Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To introduce the most general mathematical structure for discussing notions of analysis like convergence, continuity, compactness and connectedness. Notions like separation axioms, nets and filters will be introduced to emphasize that topological structures are more general than metric structures.
Learning Outcome	After going through this course, students will be able to (i) Prove results of classical analysis in a more general setting (ii) Obtain relationship of continuity with connectedness, compactness and separation axioms
Course Outline	**Unit I: Basics Topology: Marks: 20, L :15, T: 5** Open Sets, Closed Sets, Neighbourhood, Limit Point, Interior, Closure, Basis, Sub-basis, finer and coarser topology, Subspace. Continuous Functions, Open Functions, Closed Functions, Homoemorphism, Composition of Continuous Functions, Pasting Lemma, Product Topology, Quotient Topology. **Unit II: Compactness and Connectedness: Marks: 20, L :15, T: 5** Compact Space, Countable Compact Spaces, Linderloff Space, Local Compactness, Idea of Comapacttification, One point compactification,

	Stone Cech compactification, Connectedness, Path Connectedness, Local Connectedness. **Unit III: Countability, Separation Axioms, Metrisation: Marks: 20, L :15 , T: 5** The countability axioms, the separation axioms, Normal spaces, The Urysohn Lemma, The Tietze Extension theorem. Uniformities and basic definitions, Metrisation, Urysohn Metrization Theorem
Recommended Texts	1. Munkres, J. (2015). Topology, Pearson. 2. Joshi, K. D. (1983). Introduction to general topology. New Age International. 3. Simmons, G. F., Hammitt, J. K. (2017). Introduction to topology and modern analysis. New York: McGraw-Hill. 4. Murdeshwar, M.G. (1990). General topology. New Age.
Reference Books	1. Lipschutz, S. Schuam's outlines. New York: McGraw-Hill. 2. Kelley, J. L. (1975). General Topology. Springer.
Website and E-learning Source	http://mathforum.org, http://ocw.mit.edu/ocwweb/Mathematics, http://www.opensource.org

Title of the Course : Wavelet Analysis Mathematical Biology
Paper Number : 4D5
Category : DSE
Year 2
Credits 4
Course Code: MTHD16
Semester IV
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	The objective of this course is to introduce (i) Advanced Fourier Analysis (ii) The Time-Frequency Analysis (iii) The Wavelet Transform (iv) Multiresolution Analysis.
Learning Outcomes	After going through this course, students will be able to (i) Describe Audio Noising, (ii) Analyse Single Compression (iii) Develop models for Image Enhancement.
Course Outline	**Unit I: Advanced Fourier Analysis: Marks: 15, L: 12, T: 4** Introduction, The Fourier Transform in L^1 (R), Examples, Basic Properties of Fourier Transform,

	Convolution Theorem, The Fourier Transform in $L^2(R)$, Examples, Parseval's identity, Inversion formula, Plancheral's Theorem, The uncertaintity Principle, Heisenberg's Inequality **Unit II: The Time-Frequency Analysis: Marks: 15, L: 11, T: 4** Introduction, The Time-Frequency Localization, The Continuous Gabor Transforms, Examples, Properties of Gabor transformation, Parseval's Formula, Inversion formula, Conservation of energy, Frames, Discrete Gabor Transform. **Unit III: The Wavelet Transform: Marks: 15, L: 11, T: 3** Introduction, The continuous Wavelet Transform and examples, Basic properties, Perserval's Formula, Inversion Formula, The Discrete Wavelet Transform, Conservation of Energy, Frames, Orthogonal Wavelets **Unit IV: Multiresolution Analysis: Marks: 15, L: 11, T: 4** Introduction, Definition and its Consequences, Examples, Construction of Mother Wavelets with Examples, Basic Properties of Scaling Functions and Orthonormal Wavelet Bases, The Haar Multiresolution Analysis.
Recommended Text Books	1. Debnath, L., Shah, F. A. (2015). Wavelet Transforms and their Applications, Birkhauser, Boston. 2. Chui, C. K. (1992). An Introduction to Wavelets. Academic Press, New York.
Reference Books	1. Mallat, S. (1999). A wavelet tour of signal processing. Elsevier.
Website and Elearning Source	https://cseweb.ucsd.edu/-badeu/Doc/wavelets/polikar_wavelets.pdf

Title of the Course : Foundation in Mathematics
Paper Number : 2G1
Category :GE
Year 1
Credits 4
Course Code: MTHG1
Semester II
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Objectives of the Course	To build up a strong foundation of the basic Mathematical tools

Learning Objectives	After going through this course the students will be able to (i) Identify the Mathematical objects to describe social and physical systems. **(ii)** (ii) Use the Mathematical tools to address context based problems
Course Outline	**Unit I: Sets and Logic: Marks 15 L: 12, T: 3** Statements, Statements with quantifiers, compound statements, implications; Sets, Power sets, Cartesian product, countability of sets, functions and relations, graphs of functions. **Unit II: Counting Principles: Marks 15 L: 11, T: 4** Sum and Product rule of counting, permutation and combination, multinomial theorem, Pigeon hole principle, inclusion-exclusion principle, set partitions, Catalan numbers. **Unit III: Linear Algebra: Marks 15 L: 11, T: 4** Systems of Linear equations, Vector space, Linear Transformations, matrix and determinants. **Unit IV: Finite Differences and Interpolation: Marks 15 L: 11, T: 4** Introduction, Forward difference operator, Operators E and D, Backward differences, central differences, Newton forward and backward interpolation formulae, Lagrange's interpolation formula.
Recommended Text	1. Kumar, A., Kumaresan, S., Sarma, B.K. (2018). A Foundation Course in Mathematics, Narosa. 2. Kumaresan, S. (2006). Linear Algebra- A Geometric Approach, Prentice Hall India. 3. Rao, G. S. (2003). Numerical Analysis. New Age International Publishers. 4. Berge, C. (1971). Principles of combinatorics. New York, 176.
Reference Books	1. Stewart, I., Tall, D. (2015). The Foundations of Mathematics. Oxford University Press. 2. Shastry, S. S. (2012). Introductory Methods of Numerical Analysis, Prentice Hall India Learning Private Limited.
Website and Elearning Source	http:/www.mathforum.org, http:/opensource.org

Title of the Course : Mathematical Modelling
Paper Number : 3G1
Category :GE
Year 2
Credits 4

Course Code: MTHG2
Semester III
Instructional Hours (Per week)
Lecture: 3 Tutorial : 1 Lab Practical : 0 Total : 4

Prerequisites for the Course	Basic knowledge of calculus and set theory.
Objectives of the Course	The objectives of the course are to introduce the reader to solve ordinary differential equations of first and second order, also to introduce the preliminary of graph theory. To introduce the readers with some Mathematical modeling problems using differential equations and Graphs.
Learning outcome	After going through this course reader will be able to model physical problems using differential equations and graphs. After going through this course the students will be able to (i) Solve first and second order Differential equations. **(ii)** Build and solve Mathematical models using Differential Equations **(iii)** Build and solve Mathematical models using Graph Theory
Course outline	**Unit I: First and Second Order Differential Equations Marks 15 L: 12, T: 3** General and particular solutions, separation of variables, Homogeneous equations, Linear Differential Equations of first order, General and particular solutions of homogeneous and nonhomogeneous linear differential equations of second order with constant coefficients, First order systems, solution of two-dimensional systems (Simple cases) **Unit II: Mathematical Modelling Through Differential Equations Marks 15 L: 11, T: 4** Techniques of mathematical modeling, Mathematical modeling through first and second order ordinary differential equations: Linear growth and Decay models, non-linear growth and decay models, Compartment models, mathematical modeling in dynamics, Rectilinear motion, Miscellaneous models.. **Unit III: Graph Theory Marks 15 L: 11, T: 4** Introduction, Graphs and their representations, Graph terminology, Types of graphs, Fundamental and some additional theorems of graph theory, Operation on graphs, Matrix representation of a graph, Adjacency and incidence matrices. **Unit IV: Mathematical Modelling Through Graphs**

	Marks 15 L: 11, T: 4 Situations that can be modeled through graphs, Mathematical modeling in terms of directed graphs, Signed graphs, Weighted diagraphs, Non-oriented graphs.
Recommended Text	1. Edwards H. C., Penny D. E. (1995). Differential Equations and Boundary Value Problems: Computing and Modeling. Prentice Hall. 2. Kapur, J. N. (1988) Mathematical Modelling, New Age International Publishers. 3. Deo, N. (2017). Graph theory with applications to engineering and computer science. Courier Dover Publications.
Reference Books	1. Barnes, B., Fulford, G. R. (2008). Mathematical Modelling with Case Studies, CRC Press. 2. Bender, E. A. (2012). An introduction to mathematical modeling. Courier Corporation. 3. Meerschaert, M. M. (2013). Mathematical Modelling, Academic Press.
Website and E-learning Source	http:/www.mathforum.org, http:/opensource.org