# SYLLABUS & PROGRAMME STRUCTURE

**M.Sc.**

**in**

# Applied Mathematics

(Effective from the Academic Session 2019-2020)

**DEPARTMENT OF APPLIED MATHEMATICS**
**MAHARAJA BIR BIKRAM UNIVERSITY**
**AGARTALA, TRIPURA: 799004**

**_APPLIED MATHEMATICS_** Syllabus

M.Sc.Course (Two years)

Outline of the Syllabus with effect from 2019-2020

| *Course Code* | *Course Title* | *Marks* | *Credit* |
|---|---|---|---|
| | ***First Semester*** | | |
| **APPMAT-101** | **Algebra-I** | **50** | **4** |
| **APPMAT-102** | **Complex Analysis** | **50** | **4** |
| **APPMAT-103** | **Classical Mechanics** | **50** | **4** |
| **APPMAT-104** | **Differential Geometry and Tensors** | **50** | **4** |
| **APPMAT-105** | **Ordinary Differential Equations** | **50** | **4** |
| | ***Second Semester*** | | |
| **APPMAT-201** | **Algebra-II** | **50** | **4** |
| **APPMAT-202** | **Functional Analysis** | **50** | **4** |
| **APPMAT-203** | **Topology** | **50** | **4** |
| **APPMAT-204** | **Continuum Mechanics** | **50** | **4** |
| **APPMAT-205** | **Real Analysis and Partial Differential Equations** | **50** | **4** |
| | ***Third Semester*** | | |
| **APPMAT-301** | **Measure Theory and Lebesgue Integration** | **50** | **4** |
| **APPMAT-302** | **Integral Transforms and Integral Equations** | **50** | **4** |
| **APPMAT-303** | **Graph Theory** | **50** | **4** |
| **APPMAT-304** | **Numerical Analysis with Computer Applications-I** | **50 (30-Theory+ 20-Practical)** | **4** |
| | Choose any ***one (1)*** of the following *Special Papers* | | |

| | | | |
|---|---|---|---|
| **APPMAT-305A** | **Nonlinear Dynamics: Stability, Instability and Chaos** | **50** | **4** |
| **APPMAT-305B** | **Operations Research-I** | **50** | **4** |
| **APPMAT-305C** | **Mathematical Elasticity-I** | **50** | **4** |
| **APPMAT-305D** | **Fluid Dynamics-I** | **50** | **4** |
| **APPMAT-305E** | **Fuzzy Set Theory and Applications** | **50** | **4** |
| **Only the students of other departments of third semester may opt the following course** | | | |
| **APPMAT-306** | **Mathematics in Social Sciences** | **50** | **4** |
| ***Fourth Semester*** | | | |
| **APPMAT-401** | **Probability and Statistics** | **50** | **4** |
| **APPMAT-402** | **Discrete Mathematics** | **50** | **4** |
| **APPMAT-403** | **Numerical Analysis with Computer Applications-II** | **50 (20-Theory + 30-Practical)** | **4** |
| **APPMAT-404** | **Project** | **50** | **4** |
| Choose any One***(1)*** of the following *Special Papers* (* **Choice of papers:** APPMAT-305A → APPMAT-405A; APPMAT-305B → APPMAT-405B; APPMAT-305C → APPMAT-405C; APPMAT-305D → APPMAT-405D; APPMAT-305E → APPMAT-405E) | | | |
| **APPMAT-405A** | **Mathematical Biology** | **50** | **4** |
| **APPMAT-405B** | **Operations Research-II** | **50** | **4** |
| **APPMAT-405C** | **Mathematical Elasticity-II** | **50** | **4** |
| **APPMAT-405D** | **Fluid Dynamics-II** | **50** | **4** |
| **APPMAT-405E** | **Fuzzy Topology** | **50** | **4** |

# Maharaja Bir Bikram University
## Department of Applied Mathematics
## First Semester Syllabus

| | |
|---|---|
| **APPMAT-101** | **Algebra - I**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-102** | **Complex Analysis**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-103** | **Classical Mechanics**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-104** | **Differential Geometry and Tensors**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-105** | **Ordinary Differential Equations**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |

# Detailed Syllabus

**Course Title:** Algebra-I
**Course No:** APPMAT-101

**Groups:** Homomorphism of groups, Normal Subgroups, Quotient groups, Isomorphism Theorems, Cayley's Theorem.
Generalised Cayley's Theorem, Cauchy's Theorem, Group Action, Sylow Theorems, and their applications.
Normal and Subnormal series, Composition series, Solvable groups and nilpotent groups, Jordan-Holder theorem and it's applications.

**Rings:** Ideals and Homomorphism, Prime and Maximal Ideals, Quotient Field and Integral Domain, Polynomial and power series Rings.
Divisibility Theory: Euclidean Domain, Principal Ideal Domain, Unique Factorization Domain, Gauss Theorem.
Noetherian and Artinian Rings, Hilbert Basis Theorem, Chhen's Theorem.

**Modules:** Left and Right Modules over a ring with identity, Cyclic Modules, Free Modules, Fundamental structure theorem for finitely generated modules over a PID and it's application to finitely generated abelian groups.

**References :**

1. D. S. Dummit and R. M. Foote, Abstract Algebra, Second Edition, John Wiley & Sons. Inc., 1999.
2. J. K. Goldhaber and G. Ehrlich, Algebra, The Macmillan Company, Collier-Macmillan Limited, London.
3. I. N. Herstein, Topics in Abstract Algebra, Wiley Eastern Limited.
4. T. W. Hungerford, Algebra, Springer.
5. V. K. Khanna and S. K. Bhambri, A course in Abstract Algebra, Vikas Publishing House Pvt. Ltd.

**Course Title:** Complex Analysis
**Course No:** APPMAT-102

Cauchy-Riemann equations, Harmonic functions, Orthogonality of function arising out of analytic function, Cauchy-Goursat theorem, Cauchy integral formula, Morera's theorem, Cauchy inequality, Liouville's theorem, Maximum modulus theorem, Fundamental theorem of algebra, Meromorphic function, Rouche's theorem. Related Problems.

Zeros and Poles, Power series, Taylor series, Laurent series, Cauchy series, Open mapping theorem, Bilinear transformation, Conformal mapping, Schwarz lemma, Analytic continuation, Contour integration. Related Problems.

**References:**


1. J. B. Conway, Function of one complex variable, Narosa publication.
2. H. S. Kasana, Complex Variable, Prentic Hall of India.
3. S. Punnusamy, Functions of complex analysis, Narosa.
4. E. T. Copson, An introduction to theory of functions of complex variable, Oxford Clarendon Press, 1962.
5. T. M. Mac Robert, Functions of a Complex variables, Macmillan, 1962.
6. W. Rudin, Real and Complex Analysis, McGrawHill.
7. A. Gupta, Principles of Complex Analysis, Academic Publishers.

# Course Title: Classical Mechanics
## Course No: APPMAT-103

**Classical Mechanics:**

*Newtonian Mechanics:* Basic concepts, definitions and problems.
*Conservative force:* Basic concepts, definitions, related theorems and problems.
*Constraints:* Basic concepts, definitions and examples of systems with unilateral, bilateral, holonomic, non-holonomic, seleronmic, rhenomic, conservative, dissipative constraints and related problems.
*Degrees of freedom:* Basic concepts, definitions and related problems.
*Generalized Coordinates, Virtual work, D'Alembert's principle and related problems*.
*Lagrangian mechanics:* Lagrange's equation of first and second kind, Uniqueness of solution, Application of Lagrangians, Energy equation for conservative field, Cyclic or ignorable coordinates, Routhian, Liouville's class of Lagrangians. Problems related to all the topics.
*Hamiltonian mechanics:* Hamiltonian, Hamilton's canonical equations, Hamilton's principle (general and modified), Derivation of Lagrange's equations of motion, Hamilton's equations of motion from Hamilton's principle, Principle of least action, Noether's theorem. Problems related to all the topics.
*Rigid body motion:* Euler's dynamical equations, Rotating coordinate system, Foucault pendulum and torque free motion of a rigid body about a fixed point, Motion of a symmetrical top and theory of small vibrations. Problems related to all the topics.
*Canonical Transformation Theory:* Poisson's bracket, Poisson's identity, Jacobi-Poisson theorem. Hamilton Jacobi equations, Time dependent Hamilton-Jacobi equation and Jacobi's theorem, Lagrange brackets, Condition of canonical character of transformation in terms of Lagrange brackets and Poisson brackets, Invariance of Lagrange brackets and Poisson brackets under canonical transformations. Problems related to all the topics.

**Calculus of variations:**

Functional, Properties of functional, Linear and nonlinear functional, Optimal value, Euler-Lagrange equation in $n$-dimension, Extremum of a functional, Geodesic, Shortest distance between two points, The Barchistochorne problem and its solution, Applications of Barchistochorne problem.

**References:**


1. H. Goldstein, *Classical Mechanics.*
2. N. C. Rana *and* P. S. Jog, *Classical Mechanics.*
3. L. N. Hand *and* J. D. Finch, *Analytical Mechanics.*
4. A. S. Ramsey, *Dynamics Part-II,*
5. S. L. Loney, *Rigid Dynamics.*
6. Gupta, Kumar, Sharma, *Classical Mechanics.*
7. A. S. Gupta, *Calculus of Variations with Applications*

**Course Title:** Differential Geometry and Tensors
**Course No:** APPMAT-104

**Tensors :**

Linear vector spaces, linear transformation and matrices, reduction of matrices to the quadratic forms, classification and properties of quadratic forms.

Scope of tensor analysis, invariants, tensor and their transformation laws, transformation of coordinates, properties of admissible transformation of coordinates, transformation by covariance and contravariance tensor, concept of covariance and contravariance tensors, algebra of tensors, quotient laws, symmetric and skew symmetric tensors, relative tensors, metric tensors, fundamental and associated tensors.

Christoffels' symbols, transformation of Christoffels' symbols, Covariant differentiation of tensors and formula, Ricci's theorem, Rieman-Christoffels' tensors, Ricci tensor, Riemannian and Euclidean space, Existence theorem. The e-system and the generalized Kronecker's deltas.

**Curves in Space:**

Parametric representation of curves, Helix, Curvilinear coordinates in $E_3$. Tangent and first curvature vector, Frenet formulas for curves in space, Frenet formulas for curve in $E_n$. Intrinsic differentiation, Parallel vector fields, Geodesic.

**Surfaces :**

Parametric representation of a surface, Tangent and Normal vector field on a surface, The first and second fundamental tensor, Geodesic curvature of a surface curve, The third fundamental form, Gaussian curvature, Isometry of surfaces, Developable surfaces, Weingarten formula, Equation of Gauss and Codazzi , Principal curvature, Normal curvature, Meusnier's theorem.

**References:**


1. I. S. Sokolnikoff, Tensor Analysis, Theory and Applications to Geometry and Mechanics : (chapter-II and III) , John Wiley & Sons Inc N.T.
2. T. T. Wilmore, An Introduction to Differential Geometry: (Chapter – I, II, III, V and VI).
3. BARYSPAIN, Differential Geometry.
4. F. F. Goreux, Differential Geometry, New Central Book Agency, Kolkata.
5. A. K. Chakraborty, Elementary Analysis, Ram Prasad & Sons, Agra.
6. D. K. Das, Tensor Calculus, Dasgupta Publisher, Kolkata.
7. U. C. De, A. A. Shaikh, J. Sengupta, Tensor Calculus, Narosa Publishing House, New Delhi.
8. M. C. Chaki, Tensor Calculus, Calcutta Publisher, Kolkata.

# Course Title: Ordinary Differential Equations
## Course No: APPMAT-105

### ORDINARY DIFFERENTIAL EQUATIONS

Initial value problem of first order ODEs, Existence and Uniqueness of solutions of IVP, Singular solution, General theory of homogeneous and non homogeneous linear ODE, Variation of parameters,Sturn-Liouville Boundary Value Problem, Green's Function. Ascoli-Arzoli theorem, Theorem on convergence of solution of IVP, Picard –Lindeloff theorem, Piano's Existence Theorem, Systems of first order ODEs, Independence of the solution of linear differential equation, Wronskian and its properties, exact differential equation and equation of special form. Adjoint and self-adjoint equations.

### SPECIAL FUNCTIONS

Series solution by the method of Frobenius, Hypergeometric equation and Hypergeometric functions, Legendre differential equation and Legendre polynomials, Bessel's differential equation and Bessel's function. Laguerre differential equation and Lagurre polynomial, Hermite differential equation and Hermite polynomial; recurrence relations, orthogonal properties.

**References:**


1. G. F. Simmons, Differential Equations with Applications and Historical Notes,(McGraw Hill, 1991).
2. Codington and Levison, Theory of Ordinary Differential equations, Tata McGrawHill3.
3. P. Hartman,  Ordinary differential equations , John wiley and sons
4. W. T. Reid , Ordinary differential equations , John wiley and sons .
5. J. C. Burkhill , Theory of ordinary differential equations.

# Maharaja Bir Bikram University

## Department of Applied Mathematics

## Second Semester Syllabus

| | |
|---|---|
| **APPMAT-201** | **Algebra-II**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-202** | **Functional Analysis**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-203** | **Topology**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-204** | **Continuum Mechanics**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-205** | **Real Analysis and Partial Differential Equations**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |

**Course Title:** Algebra II
**Course No:** APPMAT-201

Fields, Finite fields, Extension fields, algebraic and transcendental extension, separable and normal extensions, perfect fields, algebraically closed fields.

Galois Group of automorphisms and Galois Theory, Solution of polynomial equations by radicals, Insolvability of the general equation of degree 5(or more) by radicals.

The minimal polynomial, Diagonalizable and triangulable operators, Primary Decomposition theorem, Secondary decomposition theorem,The Jordan Form, The Rational Form,

Norms of vectors and matrices, Transformation of matrices, adjoint of an operator, normal, unitary, Hermitian and skew-Hermitian operators.

Bilinear Forms, Definition and examples, symmetric and skew-symmetric bilinear forms, real quadratic forms, The matrix of a bilinear form, Orthogonality, Classification of bilinear forms.

**References:**


1. Hoffman and Kunze, LinearAlgebra.
2. A. R. Rao and P. Bhimashankaram, Linear Algebra. (Tata Mc-GrawHill)
3. M. Artin, Algebra, Prentice Hall of India.
4. Gilberd Strang, Linear Algebra and its Application, Academic Press.
5. S. Lang, Linear Algebra, Undergraduate Texts in Mathematics,Springer-Verlag.
6. P. Lax, Linear Algebra, John Wiley &Sons.
7. Ben Noble and James W. Daniel, Applied Linear Algebra (Prentice - Hall of India Private Ltd.)
8. Gareth Williams, Linear Algebra with applications, Narosa Publishing House.
9. J. K. Goldhaber, G. Ehrlich, Algebra, The Macmillan Company, Collier-Macmillan Limited, London.
10. N. Herstein, Topics in Abstract Algebra, Wiley Eastern Limited.

**Course Title:** Functional Analysis
**Course No:** APPMAT-202

Normed linear spaces, Banach spaces, Equivalent norms, Finite dimentional normed linear spaces and their completeness, Convex sets in normed linear spaces and their properties, Quotient space of normed linear space and its completeness, Riesz Lemma, Fixed point theorem and its applications.
Linear operators, Bounded linear operators, Normed linear spaces of bounded linear operators, Uniform boundedness theorem, Open mapping theorem, Closed graph theorem, Linear functionals, Hahn-Banach theorem, Dual space, Reflexivity of Banach spaces.

Inner product spaces and their properties, Hilbert spaces, Orthonormal sets, Complete orthonormal sets, Bessel's inequality, Perseval's identity, Orthogonal complement and projection theorem.
Riesz representation theorem, Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert spaces, Self-adjoint operators, Continuous linear operators, Completely continuous operators, Positive operators, Projection operators, Normal operators, Unitary operators. Introduction to Spectral properties of Bounded Linear Operators.

**References:**

1. Goffman C Pedrick, First Course in Functional Analysis, Prentic Hall of India, New Delhi.
2. B. V. Limaye, Functional Analysis, Wiley Eastern Ltd.
3. B. K. Lahiri, Functional Analysis, World Press Calcutta.
4. J. B. Conway, A Course in Functional Analysis, Springer Verlag, New York, 1990.

**Course Title:** Topology
**Course No:** APPMAT-203

**Topological spaces**: Topological structures, Base and sub base for a topology, topologies generated by classes of sets, local bases, accumulation points, closed sets, closure of a set, derived sets, interior points, exterior points, boundary of a set, neighborhood & neighborhood system, Order topology, Product topology on X × Y, convergence and limit, coarser and finer topologies, subspaces, relative topologies, equivalent definition of topologies.

**Continuity and topological equivalence**: Continuous function, continuity at a point, sequential continuity at a point, open and closed functions, homomorphic spaces, topological properties, topologies induced by functions, continuous functions, open maps, closed maps and homeomorphism,

**Separation axioms**: Separation by open sets, separation axioms and Ti spaces, subspaces, sum, product and quotient spaces, Urysohn's lemma and Metrization theorem, regular space, completely regular spaces, normal space, Tychonof space, completely normal, Housdroff space.

**Countability**: First countable spaces, second countable spaces, separation spaces and Lindeloff theorem, hereditaryproperties.

**Compact spaces**: Covers, open covers, finite sub covers compact sets, reducible compact sets, sub set of a compact space, finite intersection property, compactness and Hausdorff spaces, sequentially compact sets, locally compactsets.

**Connectedness**: Separated sets, connected sets, connected spaces, connectedness on the real lines.
**Metrizable spaces**: Definition and examples, properties, subspaces, product of metrizable spaces.

**References** :

1. J.R. Munkres, Topology, A First Course, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. J. Dugundji, Topology, Allyn and Bacon, 1966.
3. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 1963.
4. J.L. Kelley, General Topology, Van Nostrand Reinhold Co., New York, 1995.
5. J. Hocking and G. Young, Topology, Addison-Wesley Reading, 1961.
6. L. Steen and J. Seebach, Counter Examples in Topology, Holt, Reinhart and Winston, New York, 1970.
7. B.C. Chatterjee, S. Ganguly and M.R.Adhikary, A Text Book of Topology, Asian Books Pvt. Ltd.

# Course Title: Continuum Mechanics
## Course No: APPMAT-204

### Group-A

## Stress and Strain Analysis

**Analysis of strain**: Affine transformation, infinitesimal affine transformation. A geometrical interpretation of components of strain. Strain quadric of Cauchy. Transformation of strain component by changing the co-ordinate system. Principle strains, invariants, general infinitesimal deformation, compatibility equations, linear strain. Examples of strain. Finite deformation.
**Analysis of stress**: Body and surface force, specification of stress at a point, equation of equilibrium, symmetry of stress tensor, boundary conditions, transformation of stress components from an co-ordinate to another and stress invariants. Stress quadric. Mohr's diagram, mean stress, stress ellipsoid. Octahedral, normal and shearing stresses. Purely normal stress. Examples of stress. Different formulae.

### Group-B

## Fluid Mechanics

Fluid motion by Euler and Lagrangian method, Equivalence of these two methods, different types of flows, stream lines and path lines, difference between them, velocity potential, rotational and irrotational motion, equation of continuity by Euler and Lagrange, particular case of equation of motion, condition for a surface to be a boundary surface, simple problems.
Euler's dynamical equations, surface condition integration of the equation of motion, Bernoulli's theorem, equation of motion by flux method, Lagrange's hydrodynamical equation, Cauchy's integral, Performancy of irrotational motion, Helmotz's equation, Kelvin's circulation theorem, simple problems.
Motion in two dimensions, the current function, irrotational motion, source, sink and doublet, complex potential, image of a source w.r.t plane and a circle, image of a doublet w.r.t to a circle, simple problems
Vorticity, properties of vortex filament, complex potential due to a rectilinear vortex, image of a vortex w.r.t a plane, circular cylinder, two infinite rows of vortices, Karman's vortex sheet

**References:**

1. I. S. Sokolnikoff, Mathematical Theory of Elasticity , Tata Mc. Grawhill , 1997.
2. S.Valliappan, Continuum Mechanics , Oxford & IBH Publishing Co.1981.
3. P. D. S Verma, Theory of elasticity,Vikas Publishing House PVT LTD.
4. F. Charlton, Textbook of Fluid Dynamics, CBS Publishers, Delhi, 1985.
5. A. J. Choin and A. Morsden, A Mathematical Introduction to Fluid Dynamics, Springer Verlag, 1993.
6. L. D. Landau and E. M. Lipschitz, Fluid Mechanics, Pergamon Press, London, 1985.

**Course Title:** Real Analysis and Partial Differential Equations
**Course No:** APPMAT-205

**Group-A**

## Real Analysis

**Metric Space**: Definitions and examples of spaces like$R^n, C^n, l_n^p, l^p$. Open sphere, closed sphere (elements of point set theory), sequences, Cauchy sequences, Cantor intersection theorem, complete metric space, continuity and compactness, Baire Category theorem , equivalent metric , extension theorem , uniform continuity.

**Functions of bounded variation**: Properties of functions of bounded variation. Total variation, Continuous function of bounded variation, Differentiation of a function of bounded variation, Function of bounded variation expressed as the difference of the increasing functions, Absolutely continuous function, Representation of an absolutely continuous function by an integral.

**Riemann – Stieltje's integral**: Definitions and examples, integration and differentiation, the upper and lower Darboux - Stieltje's integrals.

**Group-B**

**PARTIAL DIFFERENTIAL EQUATIONS**

Formation of partial differential equations, Pfaffian differential equations - Quasi-linear equations, Lagrange's method, Charpit's method, Solution of higher order partial differential equation with constant coefficients, Cauchy problem for first order partial differential equations.
Classification of second order PDE's, Linear PDE with constant coefficients, reducible and irreducible equations. Different methods of solution. Second order PDE with variable coefficients. Characteristic curves of second order PDE. Reduction to canonical forms. D'Alembert's solution of wave equation. Solutions of PDE of second order by the method of separation of variables. Boundary value problems, Dirichlet,s and Neumann's interior and exterior problems uniqueness and continuous dependence of the solution on the boundary conditions.

**References:**


1. W. Rudin , Principle of Mathematical Analysis, Mc Grow Hill 1976.
2. T. M. Apostal , Mathematical Analysis , Narosa pub. House 1985.
3. M. H. Potter and C. B. Morrey , A first course in Real analysis, Springer.
4. D. Somasundaram and B. Choudhury, A first course in Mathematical analysis, Narosa pub. House 1999.
5. G. F. Simmons, Differential Equations with Applications and Historical Notes,(McGraw Hill, 1991).
6. Ian Sneddon, Elements of Partial Differential Equations, Mcgraw Hill.
7. K. S. Rao, Introduction to partial differential equations (Prentice Hall of India, New Delhi, 2006).
8. W. E. Williams, Partial Differential Equations, Oxford Applied Mathematics and Computing Science Series.
9. F. H. Miller, Partial Differential Equations.
10. I. G. Petrovsky, Lectures on Partial Differential Equations.

# Maharaja Bir Bikram University

## Department of Applied Mathematics

## Third Semester Syllabus

| | |
|---|---|
| **APPMAT-301** | **Measure Theory and Lebesgue Integration**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-302** | **Integral Transforms and Integral Equations**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-303** | **Graph Theory**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-304** | **Numerical Analysis with Computer Applications-I**<br>Marks-50 [End term 40 (Theory-25+Practical-15)+ Internal 10 (Theory-5+Practical-5)] Credit-4 |
| Choose any ***one (1)*** of the following *Special Papers* | |
| **APPMAT-305A** | **Nonlinear Dynamics: Stability, Instability and Chaos**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-305B** | **Operations Research-I**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-305C** | **Mathematical Elasticity-I**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-305D** | **Fluid Dynamics-I**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-305E** | **Fuzzy Set Theory and Applications**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **Only the students of other departments of third semester may opt the following course** | |
| **APPMAT-306** | **Mathematics in Social Sciences**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |

# Detailed Syllabus

## **Course Title:** Measure Theory and Lebesgue Integration

## **Course No:** APPMAT-301

**Measurable sets**

Measurable sets, Length of sets, Outer measure, Lebesgue outer measure, Properties of measurable sets, Borel sets and their measurability, Characterization of measurable sets, Regularity, Non-measurable sets.

**Measurable functions**

Definition, examples and different properties of measurable functions, step function, operations on measurable functions, characteristic function, simple function, continuous function, sets of measure zero. Borel measurable functions, Convergence in measure, Sequence of measurable functions and their properties. Egoroff's Theorem, Lusin's Theorem. Almost uniform convergence.

**Lebesgue Integration**

Lebesgue integration of single function, Lebesgue integral of a bounded function, Riemann integral, comparison of Riemann integral & Lebesgue integral. Properties of the Lebesgue integral for bounded measurable functions, Integral of non-negative measurable functions.

**References :**


1. C. D. Aliprantis and O. Burkinshaw, Principles of Real analysis, 3rd Edition, Harcourt Asia Pte Ltd., 1998.
2. H. L. Royden, Real Analysis, 3rd Edition, MacMillan, New York and London, 1988.
3. P. R. Halmos, Measure Theory, Van Nostrand, New York, 1950.
4. W. Rudin, Real and Complex Analysis, McGraw-Hill Co., 1966.
5. A. N. Kolmogorov, Meassures, Lebesgue Integrals and Hillbert Space, Academic Press, New Yorkand London, 1961.
6. P. K. Jain and V. P. Gupta, Lebesgue Measure & Integration, New Age International Pvt. Ltd.

**Course Title:** Integral Transforms and Integral Equations
**Course No:** APPMAT-302

## Group-A

**Integral Transforms:**

Fourier transform: Existence, Uniqueness, Inversion, Applications to ODE &PDE, Fourier integral Theorem, Fourier transform of the derivative. Derivative of Fourier transform. Fourier transforms of some useful functions. Fourier cosine and sine transforms. Convolution. Properties of convolution function. Convolution theorem. Mellin Transform and its inverse. Application to Boundary value problems. Hankel Transforms and its inverse. Application to Boundary value problems. Z-transform : Definition and properties. Z-transform of some standard functions. Inverse Z-transforms. Applications.

## Group-B

**Integral Equations:**

Introduction. Linear integral equations of the first and second kind of Fredholm and Volterra type, Solutions with separable kernels. Relation between integral equations and initial boundary value problems. Existence and uniqueness of continuous solutions of Fredholm and Volterra's integral equations of second kind. Solution by the method of successive approximations. Iterated kernels. Reciprocal kernels. Volterra's solution of Fredholm's integral equation. Fredholm theory for the solution of fredholm's integral equation. Fredholm's determinant D(lamda). Fredholm's first minor D(x,y,lamda) Fredholm's first and second fundamental relations. Fredholm's p-th minor. Fredholm's first, second and third fundamental theorems. Fredholm'salternatives. Hilbert-Schmidt theory of symmetric kernels. Properties of symmetric kernels. Existance of characteristic constants. Complete set of characteristic constantsand complete orthonoralmised system of fundamental functions. Expansion of iterated kernel in terms of fundamental functions. Schmidt's solution of Fredholm's integral equations.

**References:**


1. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill, 1993.
2. G. F. Roach, Green's Functions,Cambridge University Press,1995.
3. S. G. Mikhlin, Integral Equations, The MacMillan Company, New york,1964.
4. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications (Chapman &Hall/CRC).
5. Lovitt : Linear Integral Equations.
6. Tricomi : Integral Equations.
7. M. D. Raisinghania, Integral Transforms, S. Chand.

**Course Title:** Graph Theory
**Course No:** APPMAT-303

Concept of a graph, definition and notations of a graph, vertices, different types of vertices and edges, loops, simple graphs, general graph, p seudo graph, multi graph, directed and undirected graph, representation of a graph, pendant vertex, degree and parity of a vertex, relation between the sum of the degree of vertices and the member of edges, an undirected graph has an even number of vertices of odd degree, walk, path, connectivity, connected graph, diameter of a connected graph, sub graph, simple problems.

Connected components, cut points, bridges, traversible multigraphs, Konigsberg problem and its solution, Eulerian graph, Eulerian graph, Eulerian trails, any finite connected graph $G$ with two odd vertices is traversable. Hamiltonian graph, a Hamiltonian graph need not be Eulerian and vice-versa, $G$ is not connected implies $G^c$ is connected. Simple problems.

Definition of a cycle, Every $(p, q)$ graph where $q \geq p$ contains a cycle, every $(p,q)$ graph with $q \geq p - 1$ is either connected or contains a cycle, theorem regarding disconnectivity of a graph $G$ existence of a path joining two vertices, maximum number of a degree in a simple graph with $n$ vertices and $K$ components.

Matrices and graphs, incident and adjacent matrices, drawing of graph whose adjacent matrix is given, adjacent structure representation of a graph, labeled graph isomorphic and homomorphic graphs, their identifications. Simple problems.

Complete tripartite graph, trees, conditions for a graph to be a tree, a tree w ith n vertices has $(n - 1)$ edges, minimally connected graph, a graph is a tree if it is minimally connected, theorem for connectivity of a graph, spanning tree, spanning trees in a weighted graph and minimal spanning tree, digraphs, Kirchoff theorem, tournaments, every tournament for Hamiltonian path, weighted graph, shortest path algorithm Drijkstra, Kruskal and Warshall algorithms.

**References:**


1. F. Harary, Graph Theory, Addision – Wesley Publishing Co., Reading, Mass(1969).
2. Deo Narsingh, Graph Theory with application to Engineering and Computer Science, Prentice Hall of India Pvt. Ltd., New Delhi 110001 (2006).
3. Edgar G Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, Prentice Hall of India Pvt. Ltd. New Delhi 110001 (2007)
4. T. Veerarajan, Discrete Mathematics w ith Graph Theory and Combinatories, McGraw Hill Education (India) Pvt. Ltd. New Delhi 110018 (2007)

**Course Title:** Numerical Analysis with Computer Applications-I
**Course No:** APPMAT-304

***Theory:***

***Methods of Solution of a system of linear equations:*** Gauss Elimination, Gauss-Jordan, LU Decomposition, Cholesky, LDV Decomposition, QR Decomposition, Uniqueness of decomposition methods, Operational counts for different methods, Gauss-Jacobi, Gauss-Seidel, S.O.R. and S.U.R. method (with rate of convergence), Partition Method, , Ill conditioned system and their solution methods, Error analysis.

***Eigenvalue problems:*** Gerschgorin's circle theorem. Brauer's Theorem, Jacobi method, Given's method, House Holder's method, Rutishauser method, Power method, Inverse power method.

***Methods to solve nonlinear equations:*** Ramanujan's method, Secant method, Muller's method, Chebyshev's method, Graeffe's Root Squaring Method, Birge Vieta method, Lin-Bairstow method, *Methods to solve a system of nonlinear equations:* General iterative method, Newton-Raphson method, Steepest descent method.

***Finite difference method of solution of partial differential equations:*** Basic concepts, Forward, Backward, Central difference of different orders, Different types of boundary conditions, Implicit and explicit schemes, Different methods of Solution of elliptic (standard formula, 5-point diagonal method, method of residuals), parabolic (Schmidt, Crank-Nicolson, Richardson, Du Fort, Frankel method) and hyperbolic type of partial differential equations, Poisson's equation.

***Practical:***
1. Gauss-Jordon method.
2. Inverse of a matrix
3. S.O.R. / S.U.R. method
4. Relaxation method
5. Solution of one dimensional heat equation
6. Solution of Laplace equation.
7. Solution of Poisson equation.
8. Solution of one dimensional wave equation.

**References:**


1. Isacson and Keller*: Analysis of Numerical methods*
2. Ralston and Rabinowitz*: A first course in Numerical Analysis*
3. M.K.Jain: *Numerical solution of differential equations*
4. G.D.Smith *: Numerical solution of partial differential equations*.
5. O.C.Zienkiewics: *The finite element method in structural and continuum mechanics*
6. A.R.Mitchell: *The finite elements method in partial differential equations*
7. Prem K. Kytbe*: An introduction to boundary element methods.*
8. B.P.Demidovich and J.A.Maron*: Computational Mathematics*

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## Course Title: Nonlinear Dynamics: Stability, Instability and Chaos

## **Course No:** APPMAT-305A

**Linear systems:** Linear autonomous systems, existence, uniqueness and continuity of solutions, diagonalization of linear systems, fundamental theorem of linear systems, the phase paths of linear autonomous plane systems, complex eigen values, multiple eigen values, stability theorem, reduction of higher order ODE systems to first order ODE systems, linear systems with periodic coefficients.

**Nonlinear systems:** The flow defined by a differential equation, linearization of dynamical systems (two, three and higher dimension), Stability: (i) asymptotic stability (Hartman's theorem), (ii) global stability (Liapunov's second method).

**Periodic Solutions (Plane autonomous systems):** Translation property, limit set, attractors, periodic orbits, limit cycles and separatrix, Bendixon criterion, Dulac criterion, Poincare-Bendixon Theorem, index of a point, index at infinity.

**Bifurcation and Center Manifolds:** Stability and bifurcation, saddle-node, transcritical and pitchfork bifurcations, hopf- bifurcation, center manifold (linear approximation).

**Linear difference equations:** Difference equations, existence and uniqueness of solutions, linear difference equations with constant coefficients, systems of linear difference equations, qualitative behavior of solutions to linear difference equations.

**Nonlinear difference equations (Map):** Steady states and their stability, the logistic difference equation, systems of nonlinear difference equations, stability criteria for second order equations, stability criteria for higher order system.

**Delay differential equations:** Definitions and Notations, Applications, solution, stability analysis.

**Stochastic differential equations:** Definitions and Notation, Random Walk and Brownian Motion, White and Colour Noise, Diffusion Process, Kolmogorov Differential Equations, Wiener Process, Ito Stochastic Integral, Ito Stochastic Differential Equation.

**Chaos:** Feigenbaum's number, Lyapunov exponents, Butterfly effect, Examples of Chaos in various dynamical systems like Lorenz system, Rosselor system, One-dimensional logistic map etc.

**MATLAB:** Numerical simulations using MATLAB.

**References:**


1. D. W. Jordan and P. Smith (1998): Nonlinear Ordinary Equations- An Introduction to Dynamical Systems (Third Edition), *Oxford Univ.Press.*
2. *L. Perko (1991):* Differential Equations and Dynamical Systems, *Springer Verlag.*
3. *F. Verhulust (1996):* Nonlinear Differential Equations and Dynamical Systems, *Springer Verlag.*
4. *Alligood, Sauer, Yorke (1997):* Chaos- An Introduction to Dynamical Systems, *Springer Verlag.*
5. *W. G. Kelley and A. C. Peterson (1991):* Difference Equations- An Introduction with Applications, *Academic Press.*
6. *Rudra Pratap (1996): Getting started with MATLAB, Oxford.*

# **Course Title:** Operations Research-I
# **Course No:** APPMAT-305B

**Goal Programming**

Introduction, Concept of Goal Programming, Difference between LP & GP approach, Graphical solution-method of GP, Modified simplex method of GP.

**Dynamic programming**

Introduction, Characteristic of Dynamic programming, Deterministic and Probabilistic Dynamic Programming, Bellman's principle of optimality, forward and backward recursive approach, solving linear and non-linear programming problems.

**Travelling Salesman Problem**

Origin of travelling salesman problem, Symmetrical and asymmetrical problems, Mathematical representation of problems, Solution techniques for such problems using zero assignment/unit assignment etc.

**Theory of Games**

Introduction. Basic idea of theory of games. Payoff matrix. Rectangular games, Strategies, Pure and Mixed strategy problems, Minimax/Maximin criterion, Saddle point, Graphical method of solving 2 x n and m x 2 games, Dominance principle, Equivalence of rectangular games and solving games by linear programming and matrix method. Algebraic method for the solution of general game. Fuzzy game problem.

**Queueing Theory**

Introduction, Queueing system, Queue disciplines FIFO, LIFO, SIRO, FILO etc. The Poisson process (Pure birth process), Arrival distribution theorem, Properties of Poisson process, Distribution of inter arrival times (exponential process), Markovian property of inter arrival times, Pure death process (distribution of departures), Derivation of service time distribution, Kendals notations, Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space.

**References:**


1. F. S. Hiller and G.C. Leiberman, Introduction to Operations Research, McGraw-Hill, 1995.
2. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Macmillan.
3. J. K. Sharma, Operations Research: Theory and Applications, McMillan, 2013.
4. G. Hadly, Nonlinear and Dynamic Programming, Addison Wesley.
5. P. K. Gupta and D.S. Hira, Operations Research, S. Chand.
6. S. D. Sharma, Operations Research, Theory, methods & applications, Kedar Nath Ram Nath.

**Course Title:** Mathematical Elasticity-I
**Course No:** APPMAT-305C

**Equations of Elasticity:** Equations of equilibrium motion in terms of displacements, Hooke's law. Generalized Hooke's law. Various cases of Elastic symmetry of a body. The strain energy function and its connection with Hooke's law. Betti's identity. Clapeyrons formula and Clapeyrons theorem. Fundamental boundary value problems. Uniqueness and existence of solutions. Saint Venant's principle.

**Inverse and semi-inverse methods of solution:**. Extension, Bending, Torsion and Flexure of beams : Solution of torsion problem as Dirichlet or Neumann boundary value problem. Prandtl's Analogy. Conformal mapping and the general problem of Flexure. Transverse bending. Problem of Torsion and Flexure for circular and elliptic bar. Torsion of circular shafts of variable diameter.

**Plane problems:** Plane strain and plane stress. Generalized plane stress. Airy's stress function. Solution of plane problems by means of polynormials. General Equations of the plane problems in polar co ordinates.

**Thermo elasticity:** Stress-strain relations, Differential equations of heat conduction, Basic equation in dynamical thermo elasticity, Thermo elastic vibrations and waves.

**References:**


1. A. E. Love, A Treatise on The Mathematical Theory of Elasticity.
2. I. S. Sokolnikoff , Mathematical Theory of Elasticity.
3. S. Timoshenko and J. N.Goodier, Theory of Elasticity.
4. A. S. Saada, Elasticity.Theory and Applications.
5. Y. C. Fung, Foundations of Solid Mechanics.
6. Y. A. Amenzade, Theory of Elasticity.
7. ZhilunXu, Applied Elasticity.
8. J. D.Achenbach, Wave Propagations in Elastic Solids.
9. A. C.Eringen, Elasto Dynamics.
10. K. F. Graff , Wave Motion in Elastic Solids.
11. Chi-TheWang, Applied Elasticity.

**Course Title:** Fluid Dynamics-I
**Course No:** APPMAT-305D

Bernoulli"s equation. Impulsive action equations of motion and equation of continuity in orthogonal curvilinear co- ordinate. Euler's momentum theorem and D'Alemberts paradox.

Theory of irrotational motion flow and circulation. Permanence irrotational motion. Connectivity of regions of space. Cyclic constant and acyclic and cyclic motion. Kinetic energy. Kelvin's minimum. Energy theorem. Uniqueness theorem.
Dimensional irrotational motion.

Function. Complex potential, sources. sinks, doublets and their images circle theorem. Theorem of Blasius. Motion of circular and elliptic cylinders. Circulation about circular and elliptic cylinder. Steady streaming with circulation. Rotation of elliptic cylinder.
Theorem of Kutta and Juokowski. Conformal transformation. Juokowski transformation. Schwartz-Chirstoffel theorem.

Motion of a sphere. Stoke's stream function. Source, sinks, doublets and their images with regards to a plane and sphere.
Vortex motion. Vortex line and filament equation of surface formed by stream lines and vortex lines in case of steady motion. Strength of a filament. Velocity field and kinetic energy of a vortex system. Uniqueness theorem rectilinear vortices. Vortex pair. Vortex doublet. Images of a vortex with regards to plane and a circular cylinder. Angle infinite row of vortices. Karman's vortex sheet
Waves: Surface waves. Paths of particles. Energy of waves. Group velocity. Energy of a long wave.

***References:***


1. A. S. Ramsay (Bell), Hydrodynamics.
2. H. Lamb (Cambridge), Hydrodynamics.
3. L. D. Landou and E. M. Lifchiz (Pergamon), Fluid Mechanics,1959.
4. L. M. Thomson, Theoritical Hydrodynamics.
5. I. M. Milne-Thomson, Theoritical Aerodynamics, Macmillan, 1958.
6. Shih-I.Pai, Van Nostrand, Introduction to the theory of compressible flow, 1959.
7. P. Niyogi, Inviscid Gas Dynamics, Mcmillan,1975.
8. K. Oswatitsch, Gas Dynamics, Academic Press,1956.

**Course Title:** Fuzzy Set Theory and Applications
**Course No:** APPMAT-305E

**Fuzzy sets:** Definition of fuzzy sets, fuzzy point, α-level sets, convex fuzzy sets, basic operations on fuzzy sets, cardinality of fuzzy sets and relative cardinality of fuzzy sets.

**Operation on Fuzzy sets:** Cartesian products, algebraic products, bounded sum and difference, t-norms and t-conorms, quasi-coincidence of two fuzzy sub sets, rough sets (definition and example), idea of soft sets.

**Generalization and variants of fuzzy sets:** L- fuzzy sets, interval- valued fuzzy sets, type -2 fuzzy sets, intuitionistic fuzzy sets and set operations of intuitionistic fuzzy sets, Zadeh's extension principle.

**Fuzzy Arithmetic**: Fuzzy numbers, triangular fuzzy numbers, fuzzy numbers describing 'Large' , Fuzzy numbers in the set of integers , arithmetic operations on intervals and fuzzy numbers.

**Fuzzy relations and fuzzy graphs:** Fuzzy relations on fuzzy sets, composition of fuzzy relations, max-min and min-max compositions, basic properties of fuzzy relations, relation between max-min and min-max compositions, fuzzy pre order relations, fuzzy semi pre order relations and fuzzy order relations fuzzy equivalence relations, fuzzy compatibility relations, fuzzy graphs, fuzzy similarity relations, examples of different fuzzy relations.

**Fuzzy functions:** Fuzzy functions on fuzzy sets, image and inverse image of fuzzy sets and some basic theorems on fuzzy functions.

**Fuzzy matrix:** Sum, multiplication of two fuzzy matrices, idempotent fuzzy matrix and their properties.

Different methods of defuzzification, decision making in fuzzy environment and some mathematical models in fuzzy environment.

**References** :


1. H. J. Zimmermann, Fuzzy Set Theory and its applications, Allied publications Ltd. 1991.
2. G. J. Klir and B. Yuan, Fuzzy sets and Fuzzy Logic, Prentice Hall of India, 1995.
3. G. Bojadziev and M. Bojadziev , Fuzzy Sets, Fuzzy Logic, Applications, World Sci., 1995.

**Course Title:** Mathematics in Social Sciences
**Course No:** APPMAT-306

**Basic of calculus:** Concept of derivative, partial derivative, integration, solution of simple differential equations.

**Simple Ideas of Statistics and Probability Theory:** Data manipulation, Measures of central tendency (Mean, Median, Mode), Variance, Standard deviation, Skewness and Kurtosis, Correlation and Regression, Basic Probability Theory, Construction process of Index numbers.

**Use of Mathematics in Constructing Theoretical Models of Social Phenomena:** Methodology of mathematical models, Construction and analysis of mathematical models on various social phenomena: Malthusian Growth model, Logistic Model, George Homan's *The Human Group* model, Rashevsky's social behaviour models, demand-supply models, Game theory models, Schelling model etc., interpretation of mathematical results from social point of view.

**Models and Social Networks through Graphs:** Definition and notations, Social Models using directed graphs, signed graphs, weighted graphs, un-oriented graphs, Small world problems using networks.

**Artificial Intelligence:** Basic concepts and definitions. Use of artificial intelligence to interpret and analyze various social phenomena.

**Stochastic differential equations:** Definitions and Notation, Random Walk and Brownian Motion, White and Colour Noise, Diffusion Process, Kolmogorov Differential Equations, Wiener Process, Ito Stochastic Integral, Ito Stochastic Differential Equation, Application of Stochastic Differential Equations in socio mathematical models.

**References** :

1. Phillip Bonacich, Philip Lu: Introduction to Mathematical Sociology
2. Barbara Foley Meeker, Robert K. Leik: Mathematical Sociology
3. Charles A. Lave: An introduction to models in the social sciences
4. James Samuel Coleman: Introduction to mathematical Sociology
6. Peter Norvig, Stuart J. Russell: Artificial Intelligence: A Modern Approach
7. Philip C. Jackson: Introduction to Artificial Intelligence
8. S. K. Mapa: Real Analysis
9. Narsingh Deo: Graph Theory with application to Engineering and Computer Science
10. Linda J. S. Allen: An introduction to stochastic processes
11. B.R. Bhatt: Modern Probability Theory.

# Maharaja Bir Bikram University

## Department of Applied Mathematics

## Fourth Semester Syllabus

| | |
|---|---|
| **APPMAT-401** | **Probability and Statistics**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-402** | **Discrete Mathematics**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-403** | **Numerical Analysis with Computer Applications-II**<br>Marks-50 [End term 40 (Theory-15+Practical-25)+ Internal 10 (Theory-5+Practical-5)] Credit-4 |
| **APPMAT-404** | **Project**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| Choose any One***(1)*** of the following *Special Papers*<br>(* **Choice of papers:** APPMAT-305A → APPMAT-405A; APPMAT-305B → APPMAT-405B; APPMAT-305C → APPMAT-405C; APPMAT-305D → APPMAT-405D; | |
| **APPMAT-405A** | **Mathematical Biology**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-405B** | **Operations Research-II**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-405C** | **Mathematical Elasticity-II**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-405D** | **Fluid Dynamics-II**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |
| **APPMAT-405E** | **Fuzzy Topology**<br>Marks-50 (End term 40+ Internal 10) Credit-4 |

# Detailed Syllabus

## **Course Title:** Probability and Statistics
## **Course No:** APPMAT-401

### Group – A: PROBABILITY

Algebra of sets, fields and σ - fields, minimal fields, closure property of a field under finite unions and intersections of arbitrary number of fields, Borel field, point function and set function, inverse function, measurable function, Borel function, induced σ - field, random variable, condition for a variable to be random, σ - field induced by a random variable, limits of random variables, moment generating function and characteristics function their properties, uniqueness of these functions, conditions for a function to be characteristic function, inversion theorem of levy, distribution function in bivariate case, bivariate normal distribution, Simple problems.

Chebychev's inequality and its generalized form, Markov and Jensen inequations, Convergence in probability, Weaklaw of Large numbers (WLLN), condition for WLLN to hold, Bernoulli's law for large numbers, Markov and Khinchin's theorem, probability generating function(pmg), pmg for the sum of independent variables, Demoivre-Laplace theorem, Some particular distributions on the real lines namely namely uniform distribution,exponential lack of memory property, exponential distribution possesses lack of memory, connection between Poisson's and exponential distribution, $x^2$ distribution, $t$ distribution, Central limit theorem (CLT), CLT for *iid* cases, Lindeberg-Levy theorem,Simple problems.

### Group – B: STATISTICS

Universe and sample different types of sampling, sampling distributions, standard error, asymptomatic distributions, stationary distribution, methods of estimation, properties of estimators, confidence intervals, test of hypothesis, likelihood ratio-test, analysis of discrete data, chisquare, test of goodness of fit, simple problems

Statistical hypothesis, minimizing two types of errors, level of significance, Neyman-Pearson lemmas test of significance based on $t$, $x^2$ distribution, partial and multiple correlation. Simple problems.

**References:**


1. B.R. Bhatt, Modern Probability Theory, New Age International Publishers, New Delhi (2015).
2. E. Parzen, Modern Probability Theory and its application,Wiley Eastern Ltd. New Delhi (1972).
3. B.V. Gnedenko, Theory of Probability, Mir Publication, Moscow (1976).
4. A. Gupta, Ground work of Mathematical Probability and Statistics, Academic Press, Kolkata (2018).
5. Vladimir Rotor, Probability Theory, Allied Publishers, Kolkata (2003).
6. W. Feller, Introduction to Probability theory and its application,Vol.-I, Wiley Eastern, New York, (1968).
7. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand, New Delhi.
8. J. N. Kapoor and H. C. Saxena, Mathematical Statistics, S. Chand, New Delhi (2009).
9. P. Mukhopadhyaya, Mathematical Statistics, New Central Book Agency, Kolkata (1996).

**Course Title:** Discrete Mathematics

**Course No:** APPMAT-402

**Mathematical Logic:** Propositions, truth tables, logical equivalence, algebra of propositions, conditional propositions, converse, contrapositive, inverse statements, biconditional statements, tautology and contradiction, normal forms, methods of proofs, rules of inference, predicate calculus, inference theory of predicate calculus. Simple problems.

**Boolean Algebra and Logic Circuits**: Boolean algebra, unique features, basic operations, Boolean function, DeMorgan theorem, Logic gate, sum of product and product of sum form, normal form, expression of a Boolean function as a canonical form, simplification of Boolean expressions, Boolean expression from logic and switching network, implementation of logic expressions with logic gates and switching circuits. Simple problems.

**Combinatories**: Pascal's identity, Vandermonde's identity, principle of inclusion and exclusion, the pigeonhole principle and its generalization, recurrence relation, particular solution, solution of recurrence relation by using generating function, derangement, principle of mathematical induction, well ordering principle. Simple problems.

**Number Theory**: Divisibility theory, factorization in prime numbers, perfect numbers, Mersene numbers, Fermat numbers. Fermat's theorem. Gauss function, Mobius function, congruences and its elementary properties. Complete and reduced residue system, Euler's phi function, indeterminate equations, sum of two squares. Quadratic residues and congruences of second degree in one unknown. Legendre symbols, quadratic reciprocity, nonlinear Diophantine equation, Ferma's last theorem, Pell's equation, Catalan relation, Beal's equation, sum of two squares. Simple problems.

**References:**


1. T. Veer Ranjan, Discrete Mathematics with Graph Theory and Combinatories, Megrawhill Education (India) Pvt. Ltd, New Delhi (2007).
2. Thomas Koshy, Elementary Number Theory with Applications, Academic Press, USA (2005).
3. S. K. Sarkar, A Text Book of Discrete Mathematics, S. Chand, New Delhi (2012).
4. D. S. Chandra Sekharaiah, Discrete Mathematical structures, Prism Books Pvt. Ltd., Bangalore (2001).
5. C. Y. Hsing, Elementary Theory of numbers, Allied Publishers, Kolkata (1995).

**Course Title:** Numerical Analysis with Computer Applications-II
**Course No:** APPMAT-403

***Theory:***

**Numerical solution of integral equations:** Approximate solution of Fredholm equation by finite sums and degenerate Kernels, Numerical solution of Volterra equations.

**Numerical methods to solve differential equations:**
*Weighted residual and variational methods:* Collocation, Sub-domain, Least square, Galerkin, Petrov-Galerkin, Ritz method.
*Finite element methods:* Basic concepts and definitions of finite element, Linear and quadratic shape functions of line element, triangular element and quadrilateral element in natural coordinates, Solutions of differential equations using shape functions.

**Numerical Quadrature:** Gaussian Quadrature. Numerical integration over finite elements (line, triangular and quadrilateral).

***Practical:***

1. Solution of ordinary differential and partial differential equation by weighted Residual method:
   a. Least square method.
   b. Galerkin method.
2. Solution of simple boundary value problem by
   a. Finite element and
   b. Boundary element method.
3. Solution of system of Non-linear equations by Newton"s method.
4. Method of steepest descent.

**References:**


1. Berzin and Zhidnov: *Computing methods*
2. Isacson and Keller: *Analysis of Numerical methods*
3. Ralston and Rabinowitz: *A first course in Numerical Analysis*
4. M.K.Jain: *Numerical solution of differential equations*
5. G.D.Smith : *Numerical solution of partial differential equations*.
6. O.C.Zienkiewics: *The finite element method in structural and continuum mechanics*
7. A.R.Mitchell: *The finite elements method in partial differential equations*
8. Prem K. Kytbe: *An introduction to boundary element method.*
9. B.P.Demidovich and J.A.Maron: *Computational Mathematics*
10. A. Gourdin & M. Boumahrat: *Applied Numerical Methods*

**Course Title:** Project

**Course No:** APPMAT-404

Here students will have to prepare project papers/reports under supervisors and present their work through power point presentation at the time of internal as well as end term examination. They will have to submit the hard copies of their works. The works may be survey based report or may be a new finding or may be solving new problems from any standard text. Students will have to finalize their project topics in consultation with their respective supervisors.

**Course Title:** Mathematical Biology
**Course No:** APPMAT-405A

**Single Species Population Dynamics:** Insect out break model- Spruce-Budworm model; Fishery models (constant harvesting, ratio dependent harvesting, harvesting effort); Compensation model, Depensation model, Critical depensation model, Allee effect (weak, strong, weak-strong), Delay models.

**Population Dynamics of Two Interacting Species:**
Lotka-Volterra system of predator-prey interaction, Gauss's Model, Kolmogorov Model, Leslie Gower Model, Beddington-DeAngelis model, Competition models, Mutualism models, Holling's functional response of Type-I, II, III, IV. Delay models.

**Continuous models for three or more interacting species:**
Three species simple and general food chain models, Models on one prey two competing predators. Delay models.

**Deterministic Epidemic Models:**
Deterministic model of simple epidemic, Infection through vertical and horizontal transmission, General epidemic- Karmac-Mackendric Threshold Theorem, modeling of Venereal diseases, SIS, SIRS, SEIS type models. Delay models.

**Enzyme Kinetics:**
Basic enzyme reactions and rate equations, Michaelis-Menten rate equations, Lineweaver-Burk plot, Cooperative phenomena, Hill Function

**Models in Genetics:** Gene, Phenotype, Genotype, Allele, Gene pool, Homozygous, Heterozygous, Mendel's experiment, Dominant, Recessive, Hybrid, Fundamental genetic matrices, Hardy Weinberg Law, Correlation between Genetics Compositions, Application of Baye's theorem, Multiple alleles and application to blood groups, Models for genetic improvement.

**Diffusion models and Pattern formation:** General balance law, Fick's law, Diffusivity of motile bacteria, Chemical basis for pattern formation, Conditions for diffusive instability in higher dimension, Gierer and Meinhardt Model, Lotka-Volterra diffusion system.

**Models through Graphs:** Models using Directed graphs, signed graphs, weighted graphs, unoriented graphs, Genetic graphs.

**MATLAB:** Numerical simulations using MATLAB.

**References:**

1. H. I. Freedman - *Deterministic Mathematical Models in Population Ecology*
2. Mark Kot (2001): *Elements of Mathematical Ecology, Cambridge Univ. Press*.
3. D. Alstod (2001): *Basic Population Models of Ecology, Prentice Hall, Inc., NJ.*
4. N.T.J.Bailey (1975): *The Mathematical Theory of Infectious Diseases and its Application, 2nd edn. London, Griffin* .
5. J. D. Murray (1990*): Mathematical Biology, Springer and Verlag.*

**Course Title:** Operations Research-II
**Course No:** APPMAT-405B

**Sequencing**

Sequencing problems, Solution of sequencing problems, Processing n jobs through two machines, Processing n jobs through three machines, Processing of two jobs through m machines, Processing n jobs through *m* machines.

**Project Scheduling and Network : PERT and CPM**

Introduction, Basic difference between PERT and CPM, Steps of PERT and CPM Techniques, PERT and CPM Network components and precedence relationship. Project scheduling by PERT and CPM, Construction of a network, Fulkerson's *i* - *j* rule, Errors and dummies in Network, Critical path analysis, Shortest route model, Forward and backward pass methods, Floats of an activity, Project costs by CPM, Crashing of an activity, Crash-cost slope, Project Time-cost, Trade off. Solution of network problems using Simplex technique. Probability of completion of a project within a scheduled time.

**Replacement and Maintenance Models**

Introduction, Replacement problem, Types of replacement problems, Replacement of capital equipment that varies with time, Replacement policy for items where maintenance cost increases with time and money value is not considered, Replacement policy for item whose maintenance cost increases with time and money value changes at a constant rate, Group replacement policy, Individual replacement policy, Mortality theorem, Replacement and promotional problems.

**Inventory Control**

Introduction, Inventory control-Deterministic including price breaks and Multi-item with constraints, Inventory control-Probabilistic (with and without lead time). Fuzzy and Dynamic inventory models.

**References :**

1. F.S. Hiller and G.C. Leiberman, Introduction to Operations Research, McGraw-Hill, 1995.
2. Kanti Swarup, P.K. Gupta and Man Mohan, Operations Research, Macmillan.
3. J.K. Sharma, Operations Research: Theory and Applications, McMillan, 2013.
4. G. Hadly, Nonlinear and Dynamic Programming, Addison Wesley.
5. P.K. Gupta and D.S. Hira, Operations Research, S. Chand.
6. S.D. Sharma, Operations Research, Theory, methods & applications, Kedar Nath Ram Nath.

**Course Title:** Mathematical Elasticity-II
**Course No:** APPMAT-405C

**Solution by means of functions of a complex variable :** Plane Stress and Plane Strain Problems. Solution of Plane Stress and Plane Strain Problems in Polar Co ordinates. General Solution for an infinite plate with a circular hole. An infinite Plate under the Action of Concentrated Forces and Moments.

**Three dimensional problems :** Beam Stretched by its own weight.Solution of differential equations of equilibrium in terms of stresses. Stress function. Reduction of Lame and Beltrami equations to biharmonic equations. Relvin and Boussinesq-Papkovich solution. Pressure on the Surface of a Semi-infiniteBody.

**Theory of thin plates :** Basic equations for bending of plates. Boundary conditions. Navier's and Levy solutions for rectangular plates. Circular Plate. Cylindrical Bending of Uniformly Loaded Plates.

**Variational methods :** Theorems of Minimum Potential Energy. Theorems of Minimum Supplementary Energy. Uniqueness of Solutions. Reciprocal theorem of Betti and Rayleigh – applications. Solution of Eulevs equation by Ritz, Galerkin and Rantorovich method.

Solution of simple crack problem using integral equations and integral transform methods- line and penny shaped crack, determination of SIF, crack propogation, Branching and arrest phenomena.

**Reference:**


1. A Treatise on The Mathematical Theory of Elasticity – A. E.Love
2. Mathematical Theory of Elasticity - I. S.Sokolnikoff
3. Theory of Elasticity – S. Timoshenko and J. N.Goodier
4. Elasticity Theory and Applications – A. S.Saada
5. Foundations of Solid Mechanics – Y. C.Fung
6. Theory of Elasticity – Y. A.Amenzade
7. Applied Elasticity – ZhilunXu
8. Wave Propagations in Elastic Solids – J. D.Achenbach
9. Elasto-dynamics – A. C.Eringen
10. Wave Motion in Elastic Solids – K. F.Graff
11. Applied Elastity – Chi-TheWang.

**Course Title:** Fluid Dynamics-II
**Course No:** APPMAT-405D

**Basic thermodynamics of one compressible fluid:**
Six governing equations of fluid motion, crocco-vazsonyl equation. Propagation of small disturbances in a gas. mach number. Dynamics similarity of two flows. Circulation theorem. Permanence of irrotational motion. Bernoulli's integral for steady isentropic and irrotational motion. Polytropic gas. Critical speed. Equation satisfied velocity potential and stream functions. Prandtl-Mayer fluid past a convex corner.

Steady flow through a De Level nozzle. Normal and oblique shock wave shock polar diagram one dimensional similarity folw.

Steady linearised subsonic and supersonic flows. Prandtl-Glauert transformation. Flow along a wavy boundary flow past a slight corner. Jangen-rayleigh method of approximation. Thin supersonic wind Ackeret's formula.

Legendre and molenbroek transformations Chaplygin's equation for stream function. Solution of chaplygin's equation. Subsonic gas jet problem limiting line. Motion due to a two dimensional source and a vortex Karman-Tsien approximation. Two dimensional steady flow : Riemann invarience. Method of characteristic. Transonic flow. Law transonic similarity. Euler's-Tricomi equation and its fundamental solution. Hypersonic flow.

**References:**


1. Hydrodynamics –A.S.Ramsay(Bell)
2. Hydrodynamics – H. Lamb(Cambridge)
3. Fluid mechanics – L.D.Landou and E.M.Lifchiz(Pergamon),1959
4. Theoritical hydrodynamics –L.M.Thomson
5. Theoritical aerodynamics –I.M.Milne-Thomson;Macmillan, 1958
6. Introduction to the theory of compressible flow –Shih-I.Pai; Van Nostrand, 1959
7. Inviscid gas dynamics – P.Niyogi, Mcmillan, 1975(india)
8. Gas dynamics – K.Oswatitsch(english tr.) academic press, 1956

**Course Title:** Fuzzy Topology
**Course No:** APPMAT-405E

**Fuzzy topology**: Chang's definition and Lowen's definition, basic concepts, fuzzy open sets, fuzzy closed sets, fuzzy interior & fuzzy closure , fuzzy continuous function, lower (upper) semi continuous functions, their basic properties, subspaces, product spaces, quotient spaces, intuitionistic fuzzy topological spaces.

**Induced fuzzy topology**: Concept of induced fuzzy topology, weakly induced fuzzy topology–their basic properties, Relation between induced fuzzy topological space and its corresponding topological space, initial topological spaces.

**Separation axioms in fuzzy topological spaces**: Fuzzy $T_0$ space, fuzzy $T_1$ space, fuzzy Hausdorff space, fuzzy regular space, fuzzy normal space, properties and examples of these spaces.

**Fuzzy filter and fuzzy net**: Properties of fuzzy filter and fuzzy net, fuzzy filter base and their properties, fuzzy cluster point. Convergence of fuzzy net.

**Fuzzy compact spaces**: Fuzzy open cover, α-shading ( α*-shading), fuzzy compactness in the sense of Chang, fuzzy compactness in the sense of Lowen, Comparison between different compactness, N – compactness and its properties.

**Fuzzy connected space and fuzzy countability axioms**: Fuzzy countable axioms, q-separated sets, definition of fuzzy connectedness, examples and its properties, good extension of connectedness.

**Mixed Fuzzy Topology**: Definition and different types of mixed fuzzy topology and their properties.

**References**:


1. N. Palaniappan, Fuzzy Topology, Norosa 2006.
2. H. J. Zimmermann, Fuzzy Set Theory and its applications, Allied Publications Ltd. 1991.