# Ph.D. Course work

# Pre-Ph.D. Examination Syllabus
# w.e.f: A.Y:: 2021-2022

DEPARTMENT OF MATHEMATICS,
K L Deemed to be UNIVERSITY,
Koneru Lakshmaiah EducationFoundation
VADDESWARAM - 522502, ANDHRA PRADESH, INDIA.

**List of Pre-Ph.D. Courses**
**DEPARTMENT OF MATHEMATICS**
**L-T-P-S: 4-0-0-0**

| S.No | Paper 1 | Subject Code |
|---|---|---|
| 1 | RESEARCH METHODOLOGY | 21RES102 |

| S.NO | PAPER – 2 | Subject Code | PAPER – 3 | Subject Code |
|---|---|---|---|---|
| 1. | Topology | 21MAT201 | Fluid Dynamics | 21MAT301 |
| 2. | Numerical Methods | 21MAT202 | Fluid Mechanics | 21MAT302 |
| 3. | Time Scale Calculus | 21MAT203 | Tribology of Bearings | 21MAT303 |
| 4. | Number Theory | 21MAT204 | Fuzzy Algebra | 21MAT304 |
| 5. | Special Functions | 21MAT205 | Functional Analysis | 21MAT305 |
| 6. | Boundary Value Problems | 21MAT206 | Semi Groups | 21MAT306 |
| 7. | Distribution and Estimation Theory | 21MAT207 | Dynamical Systems on Time scale | 21MAT307 |
| 8. | Mathematical methods & Stochastic processes | 21MAT208 | Differential Equations | 21MAT308 |
| 9. | Statistical Inference | 21MAT209 | Cryptography | 21MAT309 |
| 10. | | | Hyper Geometric Functions and Lie groups | 21MAT310 |
| 11. | | | Queueing Theory | 21MAT311 |
| 12. | | | Sampling Theory | 21MAT312 |
| 13. | | | Differential Geometry | 21MAT313 |
| 14. | | | Inventory Model | 21MAT314 |
| 15. | | | Difference Equations | 21MAT315 |

# PAPER-II
(Courses)

**DEPARTMENT OF MATHEMATICS**

# TOPOLOGY
# SYLLABUS

## Unit –I Topological Spaces and Continuous Functions

Topological spaces, basis for a topology, the order topology, the product topology on X x Y, the sub space topology, closed sets and limit points, continuous functions, the product topology, the metric topology.

## Unit –II Connectedness and compactness

Connected spaces, connected subspaces of the real line, compact spaces, compact subspaces of the real line, limit point compactness.

## Unit –III Countability and separation axioms

The countability axioms, the separation axioms, normal spaces, the urysohn lemma, the urysohn metrization theorem.

## Unit –IV The Tychnoff Theorem

The Tychnoff Theorem, Completely Regular Spaces, The Stone –Cech Compactification.

## Unit –V Complete metric spaces and function spaces

Complete metric spaces, compactness in metric spaces, pointwise and compact convergence, ascoli's theorem.

**Note**: 1. 8 Questions to be set out of which 5 Questions to be answered.
2. Questions should be uniformly distributed from all the units.

**Prescribed text Book:**

1. Topology by **James Dugundji**; Universal Book Stall, NewDelhi.

2. Introduction to Topology by **G.F.Simmons**; Tata McGraw-Hill PublishingCompany.

**Reference Text Book:**

1. Topology by **James R.Munkres**; Prentice-Hall, Second edition.

# NUMERICAL METHODS
# SYLLABUS

**UNIT-I**

**Numerical Differentiation and Integration**

Introduction, Numerical Differentiation, Numerical Integration, Euler-Maclaurin Formula, Adaptive Quadrature Methods, Gaussian Integration, Singular Integrals, Fourier Integrals, Numerical Double Integration

**UNIT-II**

**Numerical Solution of Ordinary Differential Equations**

Introduction, Solution by Taylor's Picard's Method, Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, the Cubic Spline Method, Simultaneous and Higher Order Equations, Boundary Value Problems: Finite-Difference Method, The Shooting Method.

**UNIT-III**

**Numerical Solution of Partial Differential Equations**

Introduction, Finite-Difference Approximations, Laplace's Equation: Jacobi's Method, Gauss-Seidel Method, SOR Method, ADI Method, Parabolic Equations, Iterative Methods, Hyperbolic Equations.

**UNIT-IV**

**System of Linear Algebraic Equations**

Introduction, Solution of Centro-symmetric Equations, Direct Methods, LU- Decomposition Methods, Iterative Methods, III-conditioned Linear Systems.

**UNIT-V**

**The Finite Element Method:** Functionals- Base Function Methods of Approximation- The Rayleigh –Ritz Method –The Galerkin Method, Application to two dimensional problems- Finite element Method for one and two dimensional problems.

**Reference Books:**

1. Niyogi, Pradip, "Numerical Analysis and Algorithms", Tata McGraw –Hill
2. Balagurusamy,E., "Numerical Methods", Tata McGraw –Hill
3. Sastry, S.S., "Introduction Methods of Numerical Analysis", PHI
4. Chapra, S.C. and Canale, R.P., "Numerical Methods for Engineers", Tata McGraw Hill

**TIMSCALE CALCULUS**
**SYLLABUS**

**Eight questions are to be set and the student has to answer five in three hours of duration:**

UNIT-1
**Basic definitions**: Jump operators, left and right dense, left and right scattered, Induction principle. Differentiation, Properties Leibnitz rule, examples and applications.

UNIT-2 **Integration**: Regulated function rd-continuous, Existence of pre-antiderivative and antiderivative, Mean value theorem, chain rule, Intermediate vale theorem and L'Hopitals rule.

Unit-3 : **First order linear equations:** Hilger's complex plane, the exponential function, examples of exponential functions, The regressive linear dynamic equations, initial value problems and variation of constants formula..

Unit-4 : **Second order linear equations**: Wronskians, Linear operator, Abel's theorem, Hyperbolic and Trigonometric functions, Method of factoring, reduction of order, Euler-Cauchy equations, variation of parameters formula.

**Text Books:**

**1.** Martin Bohner and Allan Peterson, Dynamic equations on time scales, an introduction with Applications. BirKhauser, Boston.

# NUMBER THEORY
# SYLLABUS

**Unit 1: Divisibility**
Early Number Theory, The Division Algorithm, The Greatest Common Divisor, The Euclidean Algorithm.

**Unit II: Congruences**
Basic Properties of Congruence, Binary and Decimal Representations of Integers, Linear Congruences and the Chinese Remainder Theorem.

**Unit III: Fermat's Theorem**
Fermat's Little Theorem and Pseudoprimes, Wilson's Theorem.

**UNIT IV: Euler's Generalization of Fermat's Theorem**
Euler's Phi-Function, Euler's Theorem, Some Properties of the Phi-Function

**Unit V: Quadratic Reciprocity Law**
Euler's Criterion, The Legendre Symbol and Its Properties, Quadratic Reciprocity, Quadratic Congruences with Composite Moduli.

**Text Book**: David M. Burton, Elementary Number Theory, Sixth Edition, McGrawHill.

**SPECIAL FUNCTIONS**
**SYLLABUS**

**UNIT-I: The Gamma and Beta Functions**
The Gamma function,A series for $\Gamma'(z)/\Gamma(z)$,Evaluation of$\Gamma'(1)$, the Euler product for $\Gamma'(z)$, the difference equation $\Gamma(z+1) = z\,\Gamma(z)$,evaluation of certain infinite products , Euler 's integral for $\Gamma(z)$, the Beta function, the value of $\Gamma(z)\Gamma(1-z)$, the factorial function , Legendre 's duplication formula , Gauss multiplication theorem , a summation formula due to Euler .

**UNIT-II: BESSEL FUNCTIONS**
Definition of Jn (x) , Bessel's differential equation , Differential recurrence relation, A pure recurrence relation, A generating function, Bessel's integral, Index half an odd integral, modified Bessel function, orthogonality property for Jn (x).

**UNIT-III: LEGENDRE'S POLYNOMIALS**
Definition of Pn (x) , Differential recurrence relations, the pure recurrence relation, Legendre's differential equation, the Rodrigue's formula , orthogonality property , special properties of Pn (x), more generating functions, Laplace's first Integral form , Expansion of xn

**UNIT-IV: HERMITE POLYNOMIALS**
Definition of Hn (x),Recurrence relations , the Rodrigue's formula ,other generating functions ,integrals, the Hermite polynomials as 2F0, orthogonality , expansion of polynomial s, more generating functions.

**UNIT-V: LAGUERRE POLYNOMIALS**
The Laguerre polynomial definition , generating functions, , recurrence relations, the Rodrigue's formula, the differential equation , orthogonality, expansion of polynomials , special properties ,other generating functions , the simple Laguerre polynomials.

**TEXT BOOK:**
(1) Special functions by E.D. Rainville, MacMillan Company, New York, 1960.

# BOUNDARY VALUE PROBLEMS
# SYLLABUS

**Eight questions are to be set and the student has to answer five in three hours of duration:**

UNIT-1 : **System of linear differential equations:** system of first order equations, existence and uniqueness theorem, fundamental matrix, non-homogeneous linear systems, linear systems with constant coefficients.

Unit-2 : **Existence and Uniqueness of Solutions:** introduction, preliminaries, successive approximations, Picard's theorem, continuation and dependence on initial condition, existence of solutions in the large interval.
(Scope and treatment as in chapters: 4 and 5 of Text book (1))

Unit-3: **Nonlinear boundary value problems:** Kinds of boundary value problems associated with Non-linear second order differential equations, generalized Lipschitz condition, failure of existence and uniqueness of linear boundary value problems, simple nonlinear BVP, standard results concerning initial value problems.

Unit-4: **Relation between the first and second boundary value problems:** relation between uniqueness intervals, relation between existence intervals.

Unit-5: **Contraction mapping:** introduction, Contraction mappings, boundary value problems, a more generalized Lipschitz condition.
(Scope and treatment as in chapters: 1, 2 and sections 3.1 to 3.4 of chapter 3 of Text book (2) )

**Text Books:**

1. Text book of ordinary differential equations by S. G. Deo, V. Lakshmikantham and V. Raghavendra, Second edition, Tata McGraw-Hill Publishing Company Ltd, New Delhi (2002).
2. Non-linear two point boundary value problem by P. B. Bailey, L. P. Shampine and P. E. Waltman, Academic press, New York and London (1968).

**DISTRIBUTIONS & ESTIMATION THEORY**
**SYLLABUS**

**Unit 1** : **DISTRIBUTIONS**
Discrete And Continuous Distributions (Binomial,Poisson,Geometric,Hyper Geometric ,Rectangular,Normal,Gamma Distributions and their Properties),Bi-Variate and Multivariate Normal Distributions, Exponential Family of Distributions.

**Unit 11**: ***LIMIT THEOREMS***
Modes of convergence, Weak law of large numbers, Strong law of large numbers. Limiting moment generating functions, Central limit theorem.

**Unit 111**: **SAMPLE MOMENTS AND THEIR DISTRIBUTIONS**
Random sampling, sample characteristics and their distributions- x2 ,t and F distributions distribution of ( ,S2) in sampling from a normal population. Sampling from a Bi-variate normal distribution.

**Unit IV** : ***THEORY OF POINT ESTIMATION***
Problem of point estimation, Properties of estimates, Unbiased estimation, Lower bound for variance of estimate, Rao- Blackwell theorem, Method of moments, Maximum likelihood estimates, Bayes & Minimax estimation, Minimal sufficient statistic.

**Unit V** : ***CONFIDENCE INTERVAL ESTIMATION***
Shortest length confidence intervals, Relation between confidence estimation and hypothesis testing, unbiased confidence intervals, Bayes confidence intervals.

**PRESCRIBED BOOK**
**An introduction to Probability theory and Mathematical Statistics-V.K. Rohatgi, Wiley Eastern Publications first edition- 1975) [Chapters 5,6,7,8,11]**

***Additional Reading:*** Introduction to Mathematical Statistics (Fourth edition)
Robert Hogg & Allen Craig

# MATHEMATICAL METHODS AND STOCHASTIC PROCESSES
# SYLLABUS

**Unit-1: Numerical Analysis:**
Numerical solution of simultaneous Linear equations Gauss reduction- Crout Reduction-gauss Jordan Reduction – inverse Of Matrix-Iterative methods-gauss seidel iteration ,Relaxation, Inherent errors.
Numerical solution of Non-linear equations-Regular Falsi -Newton Raphson method Iterative Method of Higher order –Solutin of set of Non-Linera ewquations
Graffe's root squaring technique,Bairstow Iteration-scaling Method

**Unit-II**
**Laplace transforms:**
The Laplace Transform ,the Inverse Laplace Transform, application to differential equation and Integral and difference equations.

**Unit:III : Stochastic process**:
Stochastic process, Markov chains.

**Unit:IV:**
Markov processes with discrete state space-Poisson process and its extensions.

**Unit-V**
Markov process with continuous state space.

**SCOPE OF THE SYALLABUS**
For unit -1 ,Introduction to Numerical analysis(2ndEdition)by F.B.hiller Band,Tata Mc Graw Hill Publishing company Ltd.
For Unit-II chapter 1to IV in Theory and problems of laplace transformation by Murray B.Spegel Schaum's outline series,McGraw-Hill book company(1989)
For Unit III,IV&V Stichastic process, Medhi.J.Wiley eastern Limited .
Note:
Two- questions on each units I&II
One - questions on each units III&IV&V
One - questionof short notes type are to be set
Five questions to be answered out off 8 questions.

**STATISTICAL INFERENCE**
**SYLLABUS**

Theory of Estimation: Basic concepts of estimation, Point estimation, , methods of estimation; method of moments,
method of maximum likelihood; Unbiasedness, Minimum variance estimation, Cramer – Rao bound and its generalization, Rao Blackwell theorem, Existence of UMVUE estimators. Interval Estimation, Some results for normal population case.

Principle of Data Reduction: Sufficiency principle, Factorization criterion, minimal sufficiency, Completeness and bounded completeness, Likelihood principle, Equivariance principle.

Testing of Hypothesis: Null and alternative hypothesis, Type I and II errors error probability and power function, Method of finding tests, Neyman – Pearson lemma, Uniformly most powerful tests, likelihood ratio principle, Likelihood ratio test, Sequential probability ratio test, Some results based on normal population
Analysis of Variance: one-way classification; two-way classification; simple linear regression analysis with the normal distribution.

**Reference Books:**

1. Miller, I. and Miller, M.,"Freund's Mathematical Statistics with Applications",7th Ed., Prentice Hall PTR, 2006

2. Lehman, E.L., "Testing of Statistical Hypothesis", Wiley Eastern Ltd, 1959.

3. G. Casella, R. L. Berger, "Statistical Inference", Duxbury Press, 2002

4. Lehman, E.L., "Point Estimation", John Wiley & sons, 1984.

5. Rohatgi, V.K., "Statistical Inference", Dover Publications, 2011.

PAPER-III
(Courses)

**FLUID DYNAMICS**
**SYLLABUS**

**Unit I**
**Kinematics of Fluids in motion:** Real fluids and Ideal fluids- Velocity of a fluid at a point, Stream lines , path lines , steady and unsteady flows- Velocity potential - The vorticity vector- Local and particle rates of changes - Equations of continuity - Worked examples - Acceleration of a fluid – Conditions at a rigid boundary.

**Unit II**
**Equations of motion of a fluid:** Pressure at a point in a fluid at rest - Pressure at a point in a moving fluid - Conditions at a boundary of two inviscid immiscible fluids- Euler's equation of motion - Discussion of the case of steady motion under conservative body forces.

**Unit III**
**Some three dimensional flows:** Introduction- Sources, ranks and doublets - Images in a rigid infinite plane - Axis symmetric flows – Stokes stream function.

**Unite IV**
**Some two dimensional flows:** Meaning of two dimensional flow - Use of Cylindrical polar coordinate - The stream function - The complex potential for two dimensional , irrotational in compressible flow - Complex velocity potentials for standard two dimensional flows - Some worked examples – Two dimensional Image systems - The Milne Thompson circle Theorem.

**Unit V**
**Viscous flows:** Stress components in a real fluid. - Relations between Cartesian components of stress- Translational motion of fluid element - The rate of strain quadric and principle stresses - Some further properties of the rate of strain quadric - Stress analysis in fluid motion - Relation between stress and rate of strain- The coefficient of viscosity and Laminar flow - The Navier – Stokes equations of motion of a Viscous fluid.

**Contents :** F. Chorlton, Text Book of Fluid Dynamics ,CBS Publications. Delhi,1985.
Unit 1: Chapter 2. Sec 2.1 to 2.10.
Unit 2: Chapter 3. Sec 3.1 to 3.7.
Unit 3: Chapter 4. Sec 4.1 to 4.5.
Unit 4: Chapter 5. Sec 5.1 to 5.8.
Unit 5: Chapter 8 Sec 8.1, to 8.9.

**REFERENCE(S)**
[1] G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1984.
[2] A.J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics, Springer-Verlag, New York, 1993.
[3] S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Pvt Limited, New Delhi, 1976.
[4] R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.

# FLUID MECHANICS
# SYLLABUS

**Unit-1: Basics in Fluid Mechanics:**
The continuum hypothesis-Newtonian and Non-Newtonian fluids-Continuity equation- Navier-Stokes equations of motion –Energy equation, steady and unsteady flows.

**Unit-2: Navier-Stokes equations:**
Parallel flow through a straight channel and Couette flow-The Hagen-Poiseuille flow-The suddenly accelerated plane wall-Stokes first problem. The flow near an oscillating flat plate-Stokes second problem- Flow near a rotating disk. Parallel flow past a sphere.

**Unit-3: Boundary Layer Theory:**
Derivation of Boundary Layer equations for two dimensional flow-The separation of a Boundary Layer, Skin friction-The Boundary Layer on a flat plate.

**Unit-4: Thermal Boundary Layers in Laminar flow:**
Exact solution for the problem of temperature distribution in a viscous flow: (i)couette fiow, (ii)Poiseuille flow through a channel with flat walls. Forced and natural flows-Thermal Boundary Layer in forced flow-Parallel flow past a flat plate at zero incidence. Thermal Boundary Layers in natural flow (free convection).

**Text Books:**
**1)** Boundary Layer Theory- Dr.Herman Schlicting, Mc.GrawHill Book Company

**2)** Fluid Mechanics and Fluid Machines-S.K Som & G. Biswas

Reference Books:
1) Textbook of fluid dynamics- F. Chorlton, Van Nostrand, 1963

# TRIBOLOGY OF BEARINGS
# SYLLABUS

**Unit-I: Lubrication**
Definition, Types of lubricants, Viscosity, Types of Viscometers, Effect of temperature on Viscosity, Effect of pressure on Viscosity, Other physical properties of mineral oils.

**Unit-II: Basic Equations**
Generalized Reynolds equation, Flow and shear stress, Energy equation, Equation of state.

**Unit-III: Idealized Hydrodynamic Bearings**
Mechanism of pressure development in bearings, Plain slider bearing, Idealized slider bearing with a pivoted shoe, Step (Rayleigh step) bearing, Infinitely long journal bearing, Infinitely short journal bearing.

**Unit-IV: Squeeze Film Bearings**
Parallel surface bearing, Step bearing, A Circular cylinder near a plane, A Parallel circular plate, A Sphere near a plane, A Sphere in a spherical seat, A Rectangular plate on a plane surface, A Journal bearing.

**Unit-V: Elastohydrodynamic Lubrication**
Hydrodynamic equation, Elastic deformation, Grubin type solution, Accurate solution, Point contact, Dimensionless parameters, Film thickness equations, Different regimes in EHL contacts.

**Reference: Introduction to Tribology of Bearings – B.C.MAJUMDAR, S.CHAND**

# FUZZY ALGEBRA
# SYLLABUS

**Unit-1 Fuzzy subsets & Fuzzy sub groups**
Union of two fuzzy subgroups, fuzzy subgroup generated by a fuzzy subset, fuzzy normal subgroups, fuzzy conjugate subgroups and fuzzy characteristic subgroups, fuzzy syllow subgroups.

**Unit-2 Fuzzy sub rings and Fuzzy ideals**
Basic concepts, properties of fuzzy ideals, union of fuzzy sub rings (fuzzy ideals), fuzzy sub ring (fuzzy ideal) generated by a fuzzy subset, fuzzy ideals and homomorphism, fuzzy cosets.

**Unit-3 Fuzzy prime ideal and Maximal ideals**
Fuzzy prime ideals, fuzzy maximal ideals, fuzzy semi prime ideals, characterization of regularity.

**Unit-4 Fuzzy primary ideals**
Fuzzy primary ideals, fuzzy semi primary ideals definition and some properties, fuzzy ideals and irreducible ideals in Noetherian ring.

**Note** : 1. 8 Questions to be set out of which 5 Questions to be answered.
**2.** Questions should be uniformly distributed from all the units.

**Prescribed Text Book:**
Fuzzy Algebra by **Rajesh Kumar** ; University Press, University of Delhi, Delhi-110007.

**Reference Text Book:**
Fuzzy Commutative Algebra by **John N Mordeson & D S Malik;** World Scientific Publishing Co. Pte. Ltd.

# FUNCTIONAL ANALYSIS
# SYLLABUS

**Unit-1 Linear Metric Spaces**
Vector Spaces, Linear Metric Spaces, Normed Linear Spaces.

**Unit-2 Basic Theorems On Normed Linear Spaces**
Bounded Linear Transformations, Hahn-Banach Theorem, Open Mapping Theorem, Banach – Steinhaus Theorem.

**Unit-3 Hilbert Spaces**
Inner Product Spaces, Orthonormal Sets, Riesz Representation Theorem, Bounded Linear Operations On Hilbert Spaces.

**Unit-4 Fixed Point Theory**
The Contraction Mapping Theorem And Its Applications, Brouwer's Fixed Point Theorem And Its Applications, Schauder's Fixed Point Theorem And Some Related Results.

**Unit-5 Partial Metric Spaces**
Definitions Some Examples, Banach Fixed Point Theorem, □□□ Contraction Theorem For Four Maps And Corollaries Of This Theorem, Suziki Type Fixed Point Theorem For Single Valued Maps, W- Comparability, A Unique Common Coupled Fixed Point Theorem For Four Maps.

**Prescribed Text Book:**
Functional Analysis With Applications By **B.Choudhary** And **Sudarsan Nanda**; Wiley Eastern Limited.

# SEMI GROUPS
# SYLLABUS

**Unit-I : Functions on a semigroup**
Semigroup, special subsets of a semigroup, special elements of a semigroup, relation and functions on a semigroup, Transformations, Free semigroups.

**Unit-II : Ideals and Related concepts**
Subdirect products, Completing prime ideals and Filters, Completely semiprime ideals, Semilattices of simple semigroups, Weekly commutative semigroups, separative semigroups, -semigroups.

**Unit-III : Ideal Extensions**
Extensions and Translations, Extensions of a Weekly Reductive semigroup, strict and pure extensions, Retract Extensions, Dense extensions, Extensions of an Arbitrary semigroups, Semilattice compositions.

**Unit-IV : Completely Regular semigroups**
Completely regular, completely simple semigroups , semilattices of Rectangular groups, strong semilattice of completely simple semigroups, subdirect product of a semilattice and a completely simple semigroup.

**Unit- V : Inverse Semigroups**
The natural partial order of an inverse semigroup, partial right congruences on an inverse semigroup, Representations by one-to-one partial transformations, Homomorphisms of inverse semigroups, semilattices of inverse semigroups.

**Note :** 1. 8 Questions to be set out of which 5 Questions to be answered.
**3.** Questions should be uniformly distributed from all the units.

**Prescribed text Book :**
1. Introduction to Semigroups by **Mario Petrich; Charles E. Merrill** Publishing Company.
2. The algebraic theory of semigroups volume II, **By A.H.Clifford and G.B.Preston A**merican mathematical society.

**Reference Text Book :**
1. The Algebraic Theory of Semigroups by **A.H.Clifford and G.B.Preston;** American Mathematical Society, First edition.

# DYNAMICAL SYSTEMS ON TIME SCALES
# SYLLABUS

**Eight questions are to be set and the student has to answer five in three hours of duration:**

**UNIT-1**
**Self-Adjoint equations**:
Wronskian matrix, Lagrange Identity, Abel's formula, Hermitian, Riccati equation. Sturm's separation and Comparison theorems.

**UNIT-2**
**Linear Systems and Higher order equations**:
Regressive matrices, Existence and Uniqueness theorem, matrix exponential function, Variation of constants, Liouville's Formula, Constant coefficients.

**UNIT-3:**
**Asymptotic behavior of solutions**:
Growth and dichotomy conditions, Levinson's perturbation Lemma properties and applications.

**UNIT-4:**
**Dynamic Inequalities:**
Grownwall's Inequality, Bernoulli's Inequality, Holders and Minkowski's inequalities.Lyapunov inequalities.

**Text Book:**
Dynamic equations on time scales, an introduction with Applications. Martin Bohner and Allan Peterson, BirKhauser, Boston.

# DIFFERENTIAL EQUATIONS
# SYLLABUS

**Eight questions are to be set and the student has to answer five in three hours of duration**

**UNIT-I : System of linear differential equations:** system of first order equations, existence and uniqueness theorem, fundamental matrix, non- homogeneous linear system, linear systems with constant coefficients.

**UNIT-II : Existence and Uniqueness of solutions:** Introduction, preliminaries, successive approximations, Picard's theorem, continuation and dependence on initial condition, existence of solutions in the large interval.
*( Scope and treatment as in Chapters : 4 and 5 of Text book (1))*

**UNIT- III : Oscillation theory and boundary value problems :** Qualitative properties of solutions, the sturm comparison theorem, Eigen values, Eigen functions

**UNIT- IV : Power series solutions and special functions :** Series solutions of first order and second order linear differential equations, ordinary points, regular singular points. Gauss's hyper geometric equation, the point at infinity.

**UNIT V : Non-linear equations :** Autonomous systems, the phase plane and its phenomena, type of critical points, stability, critical points and stability for linear systems, stability by Liapunov's direct method, simple critical points of non linear systems.
*(Scope and treatment as in Chapters : 4 ,5(sections 25-29) and 8 (sections 40-44)of Text book (2))*

**Text Books :**

1. Text book of ordinary differential equations by S.G.Deo, V. Lakshmikantham and V. Raghavendra, second Edition, Tata McGraw - Hill publishing Company Ltd., New Delhi, 2002.
2. Differential equations with applications and historical Notes by George F. Simmons, Tata McGraw - Hill publishing Company Ltd., New Delhi, 1972.

# CRYPTOGRAPHY
# SYLLABUS

**Unit I: Introduction**
Encryption schemes, symmetric and asymmetric cryptosystems, cryptanalysis, alphabets and words, permutations, block ciphers and stream ciphers.

**Unit II: Perfect Secrecy**
Perfect Secrecy, Birthday Paradox, Vernam One Time Pad, Random Numbers, Pseudorandom Numbers.

**UNIT III: Public Key Cryptography**
Principle of Public Key Cryptography, RSA Cryptosystem, Cryptanalysis of RSA, Diffie-Hellman (DH) Key Exchange Protocol, Discrete Logarithm Problem (DLP), ElGamal Cryptosystem.

**UNIT IV: Cryptographic Hash Functions**
Hash and Compression Functions, Security of Hash Functions, SHA-1, Others Hash Functions, Message Authentication Codes.

**Unit V: Digital Signatures**
Security Requirements for Signature Schemes, RSA Signature, ElGamal Signature, Digital Signature Algorithm (DSA), Undeniable Signature, Blind Signature.

**Text Book**: J. Buchmann, Introduction to Cryptography, Springer (India) 2004.

**HYPER GEOMETRIC FUNCTIONS AND LIE –GROUPS**
**SYLLABUS**

**UNIT-I: THE HYPERGEOMETRIC FUNCTION**
The function F (a, b; c; z), A simple integral form, F(a,b;c;1) as a function of the parameters, Evaluation of F(a,b;c;1), The hypergeometric differential equation, F(a, b; c; z) as of its parameters, Elementary series manipulations, Simple transformations, Relation between functions of z and 1-z, A quadratic transformation, Additional properties.

**UNIT-II: GENERALIZED HYPERGEOMETRIC FUNCTIONS**
The function pFq ,The exponential and binomial functions, A differential equation , other solutions of the Differential equation , A Simple integral , The pFq with unit argument, Saalschutz's Theorem, Whippele's Theorem, Dixon's Theorem, A useful integral.

**UNIT-III: THE CONFLUENT HYPERGEOMETRIC FUNCTION**
Basic properties of the 1F1, Kummer's first and second formula, A theorem due to Kummer.
**Generating functions :** The generating function concept, generating functions of the form G(2xt – t2), sets generated by et Φ(xt), the generating functions A(t)exp(-xt/1-t).

**UNIT-IV: LIE ALGEBRAIC TECHNIQUE**
Lie groups, Lie algebras and one parameter subgroups, homomorphism, linear differential operators, Preliminary observations, The Laguerre function, Ln(α)(x), the hypergeometric function 2f1 (-n, α; β; x), the modified Laguarre function Ln(α-n)(x).

**UNIT-V: THE WEISNER METHOD**
Introduction, The differential equation, linear differential operators, group of operators, the extended form of the group generated by B and C, Generating functions for modified Laguerre polynomials, Simple Bessel functions, Gegenbauer polynomials.

**TEXT BOOK:**
(1) Special functions by E.D. Rainville, MacMillan Company, New York, 1960.

(2) A treatise on generating functions by H.M.Srivastva and H.L.Manocha, Halsted/Wiley New York, 1984.

(3) Obtaining Generating functions by Mc.Bride, springer verlag, New York, 1971.

# QUEUEING THEORY
# SYLLABUS

**Unit-I**
Concept of queuing theory, some important Random processes, Definition and Classification of Stochastic processes. Discrete-Time Markov Chains, Continuous-Time Markov chains, Birth-Death processes.

**Unit-II**
Steady state solutions M/M/1/k, M/M/m/k, M/Er/1, Er/M/1, with FCFS.

**Unit-III**
Embedded Markov chain technique, Non-Poisson queues

**Unit-IV**
Elements of priority, tandem and parallel queues.

**Unit-V**
Optimal design and control of queues. The N-Policy and the T-Policy.

**BOOKS FOR STUDY**
1. Queuing Systems, Volume I by Leonard Kleinrock(for Unit-I,II,&III)
2. Elements of queuing theory by Thomas L.Satty(for Unit-IV)
3. Introduction to Queuing theory by Robert B Cooper(for Unit-V)

**BOOKS FOR REFERENCE**
1. A first course in Bulk queues by M.L.Chaudhary and J.G. Templeten.
2. Application of queuing theory by G.F.Newell.
3. Probability, Statistics and Queuing theory with Computer Science applications by Arnold O.Allen
4. Queues by D.R.CO

Note:1. One question and each of the units I,IV&V, two questions on each of units II&III, and one question of short answer type to be set.
Note:2. Eight questions to be set out of which 5 questions to be answered.

**SAMPLING THEORY**
**SYLLABUS**

***UNIT I- SIMPLE RANDOM SAMPLING***
Simple Random Sampling, Selection of a Simple Random Sample, Definitions and Notations, Properties of the Estimates, Variances of the Estimates, Estimation of the Standard Error from A Sample, Confidence Limits, Random Sampling with Replacement, Estimation of a Ratio, Estimates of a Means over Sub Populations, Estimates of Totals Over Sub Populations, Comparison between domain Means, Validity of the Normal Approximation, Linear Estimators of the Population Mean.

***UNIT II- STRATIFIED RANDOM SAMPLING***
Description, notation, properties of the estimates, the estimated variance and confidence limits, optimum allocation, relative precision of stratified random and simple random sampling, stratification producing large gains in precision, allocation requiring more than 100 percent, estimation of sample size with continuous data, stratified sampling for proportions, estimation of sample size with proportions

***UNIT III- RATIO ESTIMATORS:***
Methods of estimation, the ratio estimate, approximate variance of the ratio estimate, estimation of a variance from a sample, confidence limits, comparision of the ratio estimate is a best linear unbiased estimator, bias of the ratio estimate ,accuracy of the formulas for the variance and estimated variance, ratio estimates in stratified random sampling, the combined ratio estimate, comparison of the combined and separate estimates, short -cut computation of the estimated variance, optimum allocation with a ratio estimate, unbiased ratio type estimates, comparison of the methods, improved estimation of the variance, comparison of two ratios, multivariate ratio estimates, product estimators

***UNIT IV- REGRESSION ESTIMATORS:***
The linear regression estimate , regression estimates with pre-assigned b, regression estimates when b is computed from the sample, sample estimate of variance. Large sample comparision with the ratio estimate and the mean per unit , bias of the linear regression estimate, the linear regression estimate under a linear regression model, regression estimates in stratified sampling, regression coefficients estimated from the sample, comparison of the two types of regression estimates

***UNIT V- SYSTERMATIC SAMPLING :***
Description, relation to the cluster sampling, variance of the estimated mean, comparison of systematic with stratified random sampling, populations in “Random”order, populations with linear trend, methods for populations with linear trends, populations with periodic variation, auto-corelated populations, natural populations, estimation of the variance from a single sample, stratified systematic sampling, systematic sampling in two dimensions, summary.

**Text Book:**
**SAMPLING TECHNIQUES by W.G. COCHRAN, Wiley, Third edition (CHAPTERS: 2,5,6,7,8 )**

**Reference Book:**
**Sampling theory by DES RAJ , McGraw Hill**

# DIFFERENTIAL GEOMETRY
# SYLLABUS

**UNIT-I:**
**Curves in the plane in space:** Curve-Arc-Length- parameterization-Level Curves vs. parameterized curves- Curvature – Plane curves – Space Curves

**UNIT-II:**
**Global properties of curves:** Simple closed curves-The Isoperimetric Inequality – The Four Vertex Theorem-Surfaces in Three Dimensions: Surface-Smooth Surfaces-Tangents, Normals and orientability – Examples of Surfaces – Quadratic

**UNIT-III:**
**The First fundamental form:** Lengths of Curves on surfaces – Isometric of Surfaces – Conformal Mappings of Surfaces – Surface Area – Equi-areal Maps and a Theorem of Archimedes-Curvature of Surfaces - The second Fundamental form–The Curvature of Curves on a Surface.

**UNIT-IV:**
**Topological spaces:** Definitions and examples–Elementary concepts-Open bases and open sub bases – Weak topologies.

**UNIT-V:**
**Compactness:** Compact Spaces -Product Spaces–Tychnoff's theorem.

**Text Books:**
1. Elementary Differential Geometry by Andrew Pressley, Springer.
2. Three Dimensional Differential Geometry by Bansilal.
3. Introduction to Topology and Modern Analysis by G.F. Simmons.
4. General Topology by Schaum series.

# INVENTORY MODELS
# SYLLABUS

**UNIT-I**

**Deterministic inventory Models**

Inventory – Types of Inventory – Inventory Decisions – Classification of Inventory Models – Concept of Average inventory – Economic Ordering Quantity (EOQ) – EOQ with shortages and without shortages - EOQ with constraints.

**UNIT-II**

**Dynamic or Fluctuating Demand Models**

Dynamic or Fluctuating Demand Models: Re-order level – Optimum Buffer stock – Inventory Control System – Deterministic Models with Price- Breaks.

**UNIT-III**

**Probabilistic Inventory Models**

Instantaneous Demand – No Set- up cost Model – Uniform Demand - No Set- up cost Model - Probabilistic order-level system with constant lead Time – Multi –period Probabilistic model with constant lead Time.

**UNIT-IV**

**Selective Inventory Management**

ABC Analysis – VED Analysis- XYZ Analysis Based on inventory value – FNSD Analysis Based on Usage rate of items.

**UNIT-V**

**Markov Analysis**

Introduction-Stochastic Process-Markov Process-Transition Probability-n-Step transition Probabilities-Markov Chain-Chapman-Kolomogrov Theorem.

**Reference Books:**

1. S.D.Sarma,"Operations Research"
2. J.Medhi,"Stochastic Processes", New Age International
3. Prem kumar Gupta,D.S.Hira,"Operations Research",S.Chand &Company Ltd.

# DIFFERENCE EQUATIONS
# SYLLABUS

**Eight questions are to be set and the student has to answer five in three hours of duration:**

**UNIT-1 :Linear difference equations:** first order equations, general results for linear difference equations, solving linear difference equations.

**Unit-2 : Methods of solving linear difference equations:** solving linear difference equations with variable coefficients, nonlinear equations that can be linearized, solving difference equations using z-transforms.
(Scope and treatment as in chapter-3 of Text book (1))

**Unit-3:Linear initial value problems associated with system of difference equations:** introduction, preliminary results from algebra, linear dependence and independence, matrix linear systems, variation of constant formula, Green's matrix, systems with constant coefficients.

**Unit-4: Qualitative properties of solutions of difference systems:** continuation and dependence on initial condition and parameters, asymptotic behavior of linear and nonlinear systems.

**Unit-5:Stability of difference systems:** Concept of stability, stability of linear and nonlinear systems.
(sections 2.1 to 2.6, 2.7 and sections 5.1 to 5.6 of Text book (2))

**Text Books:**
1. Difference equations an introduction with applications by W. G. Kelley and A. C. Peterson Second edition, Harcourt Academic Press, USA (2001).
2. Difference equations and inequalities, theory, methods and applications by R.P.Agarwal, Baker publications, Marcel Dekker Inc, New York (1992).