# M Sc – Mathematics Syllabus for 2018 Admissions Onwards
# Incorporating Changes Introduced up to June, 2019

**18MAT502** **Advanced Algebra** **3 1 0 4**

**Review: Groups and Rings**

**Unit 1**

Conjugate Elements, Normalizer of an Element, Index of Normalizer, Center of a Group, Cauchy's Theorem on Prime Order, the Number of Conjugate Classes $p(n)$ for a Permutation Group, Counting Principles, Cauchy Theorem, $p$- Sylow subgroups, Sylow's Theorems. **(Sec. 2.11 and 2.12).**

**Unit 2**

Normal Subgroups, Isomorphic Groups, External and Internal Direct Products, Cyclic Groups, Abelian Groups, Invariants of a Group, Fundamental Theorem on Finite Abelian Groups **(Sec. 2.13 and 2.14).**

**Unit 3**

Polynomial Rings over the Rational Field, Primitive Polynomials, The Content of a Polynomial, Integer Monic Polynomial, Eisenstein Criterion, Polynomial Rings over Commutative Rings. Unique Factorisation domain **(Sec. 3.10 to 3.11).**

**Unit 4**

Euclidean Domains, Principal Ideal Domains, Unique Factorization Domains, Polynomials in Several Variables over a Field and Grobner Bases. **(Sec. 8.1 to 8.3, 9.6 from Reference Book 1).**

**Unit 5**

The Elements of Galois Theory, Group of Automorphisms and its fixed field, Galois Group, The Fundamental Theorem of Galois Theory, Solvable Groups, Solvability by Radicals, Galois Groups over the Rationals.
**(Sec. 5.6 to 5.8).**

**TEXTBOOKS:**

1. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

**REFERENCES**

1. D.S. Dummit and R. M. Foote, 'Abstract Algebra', 2nd Ed., John Wiley, 2002.
2. M.Artin, 'Algebra', Prentice Hall inc 1994.
3. Joseph Rotman,'Galois Theory', 2nd Ed., Springer, 2001.

**Note:** The Problems are to be referred from Reference Book 1.

**18MAT503 Advanced Real Analysis 3-1-0-4**

**Unit 1**
Riemann-Stieltjes Integral: Definition and Existence of the Integral, Properties of the Integral, Integration and Differentiation, Integration of vector-valued functions, Rectifiable curves.
(Chapter 6: 6.1 to 6.5)

**Unit 2**
Sequences and Series of Functions: Sequence of functions and its point-wise limit, Discussion of main problems, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation, Equicontinuous Families of Functions, The Stone-Weierstrass Theorem.
(Chapter 7: 7.1 to 7.7)

**Unit 3**
Some Special Functions: Introduction to power series, The Exponential and Logarithmic Functions, The Trigonometric Functions, The Algebraic Completeness of the Complex Field.
(Chapter 8: 8.1 to 8.4)

**Unit 4**
Some Special Functions and Functions of Several Variables: Fourier series, Gamma function and its properties. Linear Transformation, Differentiation.
(Chapter 8 & 9: 8.5 to 8.6. 9.1 to 9.2)

**Unit 5**
Functions of Several Variables: The Contraction principle, The inverse function theorem, The implicit function theorem
(Chapter 9: 9.3 to 9.5)

***TEXTBOOK:***

1. *Rudin. W, "Principles of Mathematical Analysis", McGraw-Hill International Editions, Third Edition, 1976.*

***REFERENCE BOOKS:***

1. *H.L. Royden and P.M.Fitzpatrick, "Real Analysis", Pearson Education Asia Limited, Fourth Edition, 2010.*
2. *Tom M. Apostol, "Mathematical Analysis", Narosa publishing house, New Delhi, Second Edition, 1989.*

**18MAT504 ORDINARY DIFFERENTIAL EQUATIONS 3 1 0 4**

**Prerequisite: The students must know the basic concepts on ordinary differential equation.**

**Unit 1**
Linear differential equations: Introduction, initial value problems, the wronskian and linear independence, reduction of order of a homogeneous equation, non-homogeneous equation.

**TB2 (3.1-3.6)(4 hours)**

**Existence - Uniqueness of Solutions to First Order Equations:** Equations with variable separated, Exact equations, the method of successive approximations, Lipschitz condition, Convergence of successive approximations, Non–local existence of solutions, Approximations to, and uniqueness, of solutions.

**TB2 (5.2- 5.8)(10hours)**

**Unit 2**

Systems of first order equations, Existence and uniqueness theorem, fundamental matrix, nonhomogenous linear systems, linear systems with constant coefficients. **TB3 (4.2-4.7)(10 hours)**

An example – central forces and planetary motion, Some special equations.
**TB2 (6.2- 6.3)(4 hours)**

**Unit 3**

Complex n-dimensional space, Systems as vector equations, Existence and uniqueness of solutions to systems, Existence and Uniqueness of linear systems, Equations of order n.
**TB2 (6.4- 6.8) (10 hours)**

**Unit 4**

**Nonlinear equations:** Autonomous Systems, The Phase plane and its phenomena, Types of critical points. Stability, critical points and stability for linear systems, Stability by Liapunov's Direct method, stability by eigen values, Simple critical points of nonlinear systems.**TB1 (11.58- 11.62) (10 hours)**

**Unit 5**

Nonlinear mechanics, Conservative systems, Periodic solutions, The Poincaré–Bendixson theorem.
Oscillations and the Sturm Separation theorem, The Sturm comparison theorem.
**TB1 (11.63- 11.64), (4.24-4.25) (7 hours)**

**TEXTBOOKS:**


1. George F. Simmons and John S Robertson, Differential equations with applications and historical notes, Tata McGraw Hill Education Private Limited, Second Edition, 2003.
2. E.A. Coddington, An introduction to ordinary differential equations, PHI learning, 1999.
3. S. G. Deo, V. Lakshmikantham and V Raghavendra, Text book of Ordinary differential equations, McGraw Hill Education Private Limited, second edition, 2013.


**REFERENCE:**


1. William E. Boyce and Richard C. DiPrima, Elementary differential equations and boundary value problems Wiley india, 9th edition, 2012.


**18MAT505 Stochastic Processes 3 1 0 4**

**Unit – I** Introduction to Probability and Stochastic Processes:

Definition of Stochastic Processes, specification of Stochastic processes, Stationary processes– Markov Chains: definition and examples, higher transition probabilities, Generalization of Independent Bernoulli trails, classification of states and chains.
(Sections: 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 3.4)

**Unit – II** Markov Processes with Discrete State Space:

Poisson process, Poisson process related distributions, properties of Poisson process, Generalizations of Poisson Processes, Birth and death processes, continuous time Markov Chains.
(Sections: 4.1, 4.2, 4.3, 4.4, 4.5)

**Unit – III Markov processes with continuous state space:**

Brownian motion – Wiener Process - Differential equations for a Wiener process – Kolmogorov equations – first passage time distribution for Wiener process – Ornstein-Uhlenbech process.
(Sections: 5.1 to 5.6)

**Unit – IV Renewal processes and theory:**

Renewal process – Renewal processes in continuous time – Renewal equation – stopping time – Wald's equation – Renewal theorems.
(Sections: 6.1 to 6.5)

**Unit – V Branching Processes:**

Introduction, properties of generating functions of Branching process, Distribution of the total number of progeny, Continuous-Time Markov Branching Process, Age dependent branching process: Bellman-Harris process.
(Sections: 9.1, 9.2, 9.4, 9.7, 9.8)

**Text Book:**

1. J. Medhi, "Stochastic Processes", 2nd Edition, New Age International Private limited, 2006.

**Book for Reference:**

1. Sheldon M. Ross, "Stochastic Processes", 2nd Edition, Wiley, 1995.
2. J. Ravichandran, "Probability and Random Processes for Engineers", 1st Edition, IK International, 2015.

**18MAT511 ADVANCED COMPLEX ANALYSIS 3 1 0 4**

**Unit 1:**
**Schwarz Reflection**: Schwarz Reflection by complex conjugation, Reflection along analytic Arcs, Application of Schwarz Reflection (Chapter 9)

**Unit 2**
**The Riemann Mapping Theorem:** Compact sets in Function Spaces, Statement and Proof of the the Riemann Mapping Theorem, Behaviour at the Boundary ( Chapter 10).

**Unit 3**
**Analytic Continuation:** Analytic Continuation along a curve, Monodromy Theorem, the Dilogrithm, Bloch-Wigner Function, Picard's Theorem and its Application (Chapter 11)

**Unit 4**
**Entire and Meromorphic Functions:** Infinite Products, Absolute Convergence, Weierstrass Products, Functions of Finite Order, Canonical product, Minimum Modulus Theorem, Hadamard's Theorem, Mittag-Leffler Theorem (Chapter 13) .

**Unit 5**
**Elliptic Functions:** Liouville Theorem, Fundamental Parallelogram, Elliptic Function, Weierstrass Function, Addition Theorem, Sigma and Zeta Functions (Chapter 14)

**TEXTBOOK**
Serge Lang, 'Complex Analysis' Springer, 4th Edition, First Indian Reprint 2005.

**REFERENCES**
1. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Springer, 2006.

2. R. Roopkumar, Complex Analysis, Pearson Education, 2014, Chennai

*3. Lars V. Ahlfors, Complex Analysis, 2nd Edition, McGrawHill, New York, 1966*

**18MAT512 Advanced Topology 3 1 0 4**

**Unit 1**

***Continuous Functions :***

Continuous functions , homeomorphisms, Rules for Constructing continuos Functions, Pasting Lemma, the product topology, Projection, Box and Product topologies, the metric topology, Metrizable Space, Uniform metric and Uniform Topology, Sequence Lemma, Uniform Convergence, Uniform Limit Theorem.

Chapter 2: Sections 18 to 21

**Unit 2 Connectedness:**

Connected spaces, separation, connected subspaces of the Real line, Linear Continuum, Intermediate Value Theorem, Path and Pathe connectedness , Components, Path Components, locally connected, Locally Path Connected.

Chapter 3: Sections 23 to 25.

**Unit 3 Compactness:**

Compact spaces , Covering and Open Covering, Tube Lemma, Finite Intersection Property, Compact subspaces of the Real line, Extreme Value Theorem, Lebesgue Number Lemma, Uniform Continuity Theorem, Limit Point Compactness , Sequentially Compact, Local Compactness Compactification, One Point Compactification,.

Chapter 3: Sections 26 to 29

**Unit 4 Countability and Separation Axioms**

The First and Second Countability Axioms , The separation Axioms, Regular and Normal spaces, The Urysohn Lemma, Completely Regular Spaces, The Urysohn metrization

Theorem , Imbedding Theorem, The Tietze extension theorem.

Chapter 4: Sections 30 to 35

**Unit 5 The Tychonoff Theorem and Baire Space**

Tychonoff's Theorem , Baire Spaces, Baire Category Theorem.

Chapter 5: Section 37 and Chapter 8: Section 48

**TEXTBOOK:**

J.R. Munkers- "Topology" -Prentice Hall of India -2002- Second Edition.

**REFERENCE BOOKS :**

1.J. Dugundji -" Topology" Allyn and Bacon, Boston-1966.

2.K. D. Joshi -"Introduction to General Topology" Wiley Eastern Limited -2012- Revised Edition

3.M. A. Armstrong "Basic Topology" Springer (India) – 2005

4.S. Kumaresan-"Topology of Metric Spaces"- Narosa Publishing House, New Delhi, 2011- Second Reprint.

5.G.F.Simmons-"Introdution to Topology and Modern Analysis" McGraw Hill Education- 2004

**18MAT513 PARTIAL DIFFERENTIAL EQUATIONS 4 0 0 4**

**Prerequisite:** The students must know the basic concepts on Calculus (both differential and integral), Differential Equations (ODE and PDE at UG Level), either metric space or topology to understand the words open set, closed set, compact, connected, region, continuous function, Vector Calculus in which the notion of curves, surfaces, tangent plane, normal, surface integral and volume integral and their evaluation, Fourier series and Fourier transforms.

**Unit 1**

Geometrical interpretation of a first-order pde, method of characteristics and general solutions, Monge cone, Lagrange's equations, canonical forms of first-order linear equations, method of separation of variables.

**Tb1:(2.4-2.8)**

**Unit 2**

Second-order equations in two independent variables, canonical forms, equations with constant coefficients, general solutions.

**Tb1: (4.1-4.6)**

**Unit 3**

The Cauchy problem, the Cauchy-Kowalewskaya theorem, homogeneous wave equations, the D'Alembert solution of wave equation, initial boundary-value problems, equations with nonhomogeneous boundary conditions, vibration of finite string with fixed ends,.(review) nonhomogeneous wave equations.

**Tb1:(5.1-5.7)**

**Unit 4**

Basic concepts, types of boundary-value problems, maximum and minimum principles, uniqueness and continuity theorems. Dirichlet problem for a circle, Dirichlet problem for a circular annulus, Neumann problem for a circle, Dirichlet problem for a rectangle, Dirichlet problem involving the Poisson equation, the Neumann problem for a rectangle

**Tb1:(9.1-9.10)**

**Unit 5**

Derivation of the heat equation and solutions of the standard initial and boundary value problems, uniqueness and the maximum principle, time-independent boundary conditions, time-dependent boundary conditions.**TB2: (3.1-3.4) (10 hours)**

**TEXTBOOKS:**


1. Tyn Myint-U, Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers,
   Birkhauser, Boston, Fourth Edition, 2007.
2. D. Bleecker, G. Csordas, Basic Partial Differential Equations, Van Nostrand Reinhold, New York, 1992.


**REFERENCES:**


1. L.C. Evans, Partial Differrential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, Providence, 1998.
2. I.N. Sneddon, Elements of partial differential equations, McGraw Hill, New York, 1986.
3. E. Zauderer, Partial Differrential Equations of Applied Mathematics, John Wileys & Sons, New York, 2nd edition, 1989.
4. E. C. Zachmanoglou and D. W. Thoe, Introduction to Partial Differential Equations with Applications, Dover Publication, New York, 1986.


**18MAT514 MEASURE THEORY 3 1 0 4**

**Unit 1** (Sections: 2.1 to 2.5 of [1])

Measure on the Real Line: Lebesgue Outer Measure - Measurable Sets – Regularity - Measurable Functions - Borel and Lebesgue Measurability

**Unit 2** (Sections: 3.1 to 3.4 of [1])
Integration of Functions of a Real Variable: Integration of Non-Negative Functions - The General Integral - Integration of Series - Riemann and Lebesgue Integrals.

**Unit 3** (Sections: 5.1 to 5.6 of [1])
Abstract Measure Spaces: Measures and Outer Measures - Extension of a Measure - Uniqueness of the Extension - Completion of a Measure - Measure Spaces - Integration with Respect to a Measure.

**Unit 4** (Sections: 6.1 to 6.5 of [1])
Inequalities and the $L^p$ Spaces: The $L^p$Spaces - Convex Functions - Jensen's Inequality - The Inequalities of Holder and Minkowski - Completenessof$L^p(\mu)$.

**Unit 5** (Sections: 8.1 to 8.4 of [1])
Signed Measures and their Derivatives: Signed Measures and the Decomposition - The Jordan Decomposition - The Radon-Nikodym Theorem - Some Applications of the Radon-Nikodym Theorem.

**TEXTBOOK:**

1. Measure Theory and Integration by G.de Barra. First Edition. New Age International Publishers, Reprint 2000.

**Reference Book:**

1. Real Analysis by H.L. Royden and P.M.Fitzpatrick. Fourth Edition. Pearson Education Asia Limited, 2010.
2. Elias M. Stein & Rami Shakarchi**,** Real Analysis Measure Theory, Integration, and Hilbert Spaces (Princeton Lectures in Analysis), Princeton university press, 2007.

**18MAT515 NUMERICAL ANALYSIS 3 0 0 3**

Prerequisites: Calculus and Algebra

Unit I:

Review of errors and error propagation theorem;

(Roots of Transcendental and Polynomial Equations, Solution of equations in one variable: Rate of convergence for fixed point iteration method and Newton-Raphson method etc.;

System of nonlinear equations: Newton's Method, Steepest-Descent Method; (B1-10.2 and 10.4)

Solution of System of Linear Algebraic Equations: Decomposition method (LU), Ill-conditioned system, Iteration methods: Gauss-Jacobi method, Gauss- Seidel method; (B2-2.2, B2-2.4, B2-2.5)

Eigenvalues and Eigenvectors: Ghershgorin theorem, Inverse power method. (B1-7.2, B3-3.6)

**12 Hours**

Unit II:

Interpolation, Extrapolation and Approximation: Interpolating polynomials using finite differences, Hermite interpolation, Cubic-Spline interpolation, Richardson's Extrapolation. (B1-3.3, B1-3.4, B1-3.5, B1-4.2)

Numerical Differentiation: Numerical differentiation (Methods based on Interpolation, Finite difference operators, undetermined co-efficient); (B3-5.2)

Numerical integration: Trapezodial, Simpson's 1/3rd, $3/8^{th}$ rule, Gaussian Quadrature, Multiple integrals. (B1-4.3)

**10 Hours**

Unit III:

Solutions of Ordinary Differential Equations: System of higher order differential equations, Stability, Stiff Differential equations; (B1-5.9, B1-5.10, B1-5.11)

Boundary value Problems of ODE: Shooting Method (B1-11.1, B1-11.2).

**8 Hours**

Unit IV:

Solutions of Differential equations: Introduction to Finite element method: Mathematical Background, Finite Elements for ordinary differential equations, Finite Elements for ordinary differential equations, (B2-9.1, 9.2).

**10 Hours**

Unit V:

Finite Elements for partial differential equations: Heat equations (Parabolic and Elliptic PDE) and Wave equations (Hyperbolic PDE) (B2- 9.3).

**10 Hours**

TEXTBOOKS:

1. R.L. Burden, J. D. Faires, Numerical Analysis, Richard Stratton, 2011, 9th edition.

2. C. F. Gerald, P.O. Wheatley, Applied Numerical Analysis, Pearson Publishers, 2013,7th edition.

3. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, New Age International Publishers, 2007, 5th edition.

Reference Books:

4. E. Kreyszig, Advanced Engineering Mathematics, Wiley Publishers, 2015, 10th edition.

5. R.R. Bhat, S. Chakraverty, Numerical Analysis in Engineering, Narosa Publishing House, 2011.

**18MAT581 Mathematics Lab 0 0 2 1**

- **Introduction to a Mathematical software**
- **Explorations of various applications**
- **Implementation of Mathematical techniques.**

## 18MAT582 Numerical Computations Lab 0 0 2 1

- Finite Element Methods using MAT LAB or Finite element tools.

**18MAT601 Advanced Graph Theory 3 1 0 4**

**Unit 1**
**Review of Graphs:** Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm.
**Trees:** Trees, cut-edges and cut-vertices, spanning trees, minimum spanning trees, DFS, BFS algorithms.

**Unit 2**
**Connectivity:** Graph connectivity, k-connected graphs and blocks.
**Euler and Hamilton Graphs:** Euler graphs, Euler's theorem. Fleury's algorithm for Eulerian trails. Necessary / sufficient conditions for the existence of Hamilton cycles, Chinese-postman problem, approximate solutions of traveling salesman problem
**Unit 3**
**Matching:** Matchings, maximal matchings. Coverings and minimal coverings. Berge's theorem, Hall's theorem, Tutte's perfect matching theorem, Job assignment problem. Coverings, Independent Sets and Cliques; Basic Relations.

**Unit 4**
**Colorings**: Vertex colorings, greedy algorithm and its consequences, Brooks' theorem. Edge-colorings, Vizing theorem on edge-colorings.

**Unit 5**
**Planar graphs**: Euler formula. Dual graphs. Kuratowaski's Characterization, Planarity testing algorithm.

***TEXTBOOKS***
*J.A. Bondy and U.S.R. Murty, Graph Theory and Applications, Springer, 2008.*

***REFERENCES BOOKS***
1. *D.B. West, Introduction to Graph Theory, P.H.I. 2010.*
2. *Frank Harary, Graph Theory, New York Academy of Sciences, 1979.*
3. *Russel Merris, Graph Theory, John Wiley, 2011.*

**18MAT602 FUNCTIONAL ANALYSIS 3 1 0 4**

**Unit 1**(Sections: 3.1 to 3.5 of [1])
Normed Linear Spaces: Linear Spaces – Normed Linear Spaces – The Metric on a Normed Linear Space – Linear Subspaces – Bounded Linear Transformations.

**Unit 2**(Sections: 3.7 to 3.9 and 4.1 to 4.2 of [1])
Linear Homeomorphisms – An Elementary Integral – Regulated Mappings – Integration and Differentiation - Review of Compact Metric Spaces – Basic Results on Compact Subsets of a Metric Space – Separability of Compact Metric Spaces – Conditions Equivalent to Compactness - Borel – Lebesgue Theorem.

**Unit 3**(Sections: 4.3 to 4.6 of[1])
Compactness and Continuity – Dini's Theorem - Finite Dimensional Normed Linear Spaces – Completeness – Stone Weierstrass Theorem – Weierstrass Theorem on approximation of periodic functions by trigonometric polynomials – Extension of Stone-Weirstrass Theorem to $C_c(X)$ - Separability of $C_K(X)$ - Ascoli-Arzela Theorem – Peano's Theorem.

**Unit 4**(Sections: 5.1 to 5.4 of [1])
Bounded Linear Functionals – Some Dual Spaces – The Hahn-Banach Theorem – The Existence of Bounded Linear Functionals – Reflexivity of the Banach Space $l^p$ - Annihilators.

**Unit 5**(Sections: 5.5 to 5.7 of[1])
A Theorem on Convex Sets – The Riesz Representation Theorem – Hergoltz's Theorem.

***TEXTBOOKS:***
1. Elements of Functional Analysis by A.L. Brown and A. Page, Van Norstrand Reinhold Company, London,1970.

**References:**
1. Functional Analysis by Balmohan V Limaye, New Age International Publishers, Third Edition, Reprint 2014.
2. Introduction to Topology and Modern Analysis by G. F. Simmons, McGraw Hill Education, 2004

3.Thamban Nair, Functional Analysis: A First Course, PHI, 2001.

**18MAT603 Basic Fluid Dynamics 3 1 0 4**

**Unit 1**
Kinematics of Fluids in motion – Lagrangian and Eulerian methods – Equation of continuity – Boundary conditions – Kinematic and physical – steam line, path line and streak line – velocity potential – vorticity - rotational and irrotational motion.

**Unit 2**
Equation of Motion of Compressible Viscous Fluid (Navier-Stokes Equations) - General Properties – Equation of motion of inviscid fluid – Euler's equation – impulsive force – physical meaning of velocity potential - energy equation.

**Unit 3**
Lagrange's hydrodynamical equations - Bernoulli's equation and its applications - Motion in two-dimensions and sources and sinks – irrotational motion – complex potential - Milne-Thomson circle theorem – Blasius theorem.

**Unit 4**
General theory of irrotational motion – flow and circulation – Stoke's theorem – Kelvin's Circulation theorem – Permanence of irrotational motion - Kelvin's minimum energy theorem - Viscous Incompressible flow - Dimensional Analysis – Buckingam $\pi$ theorem.

**Unit 5**
Exact Solutions of Navier Stokes Equations – Small Reynold's number flows – flow past a sphere – Stokes flow – Whitehead's paradox - Flow past a circular cylinder – Stoke's Paradox.

TEXT BOOKS / REFERENCES:

*1.* G.K.Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press, 1997.
*2.* L.M. Milne-Thompson, "Theoretical Hydrodynamics", Dover Publications, 1968.
*3.* Victor L. Streeter and E.Benjamin Wylie, "Fluid Mechanics", Mc Graw Hill, 1983.
*4.* S.W. Yuan, "Foundations of Fluid Mechanics", Prentice Hall, New Jersey, 1970.


**18MAT611 Operator Theory 4 0 0 4**

Compact operators on Hilbert Spaces. (a) Fredholm Theory (b) Index, $C*$- algebras - noncommutative states and representations, Gelfand-Neumark representation theorem, Von-Neumann algebras; projections, double commutant theorem, $L\infty$ functional calculus, Toeplitz operators.

Reference Books:


1. W. Arveson, "An invitation to C*-algebras", Graduate Texts in Mathematics, No. 39. Springer-Verlag, 1976.
2. N. Dunford and J. T. Schwartz, "Linear operators. Part II: Spectral theory. Self adjoint operators in Hilbert space", Interscience Publishers John Wiley i& Sons 1963.

3. R. V. Kadison and J. R. Ringrose, “Fundamentals of the theory of operator algebras. Vol. I. Elementary theory”, Pure and Applied Mathematics, 100, Academic Press, Inc., 1983.
4. V. S. Sunder, “An invitation to von Neumann algebras”, Universitext, Springer-Verlag, 1987.

**18MAT631 ALGEBRAIC GEOMETRY 3 0 0 3**

**Unit 1 AFFINE AND PROJECTIVE VARIETIES**

Noetherian rings and modules; Emmy Noether's theorem and Hilbert's Basissatz; Hilbert's Nullstellensatz; Affine and Projective algebraic sets; Krull's Hauptidealsatz; topological irreducibility, Noetherian decomposition; local ring, function field, transcendence degree and dimension theory; Quasi-Compactness and Hausdorffness; Prime and maximal spectra; Example: linear varieties, hypersurfaces, curves.

**Unit 2 MORPHISMS**

Morphisms in the category of commutative algebras over a commutative ring; behaviour under localization; morphisms of local rings; tensor products; Product varieties; standard embeddings like the segre- and the d-uple embedding.

**Unit 3 RATIONAL MAPS**

Relevance to function fields and birational classification; Example: Classification of curves; blowing-up.

**Unit 4 NONSINGULAR VARIETIES**

Nonsingularity; Jacobian Criterion; singular locus; Regular local rings; Normal rings; normal varieties; Normalization; concept of desingularisation and its relevance to Classification Problems; Jacobian Conjecture; relationships between a ring and its completion; nonsingular curves.

**Unit 5 INTERSECTIONS IN PROJECTIVE SPACE**

Notions of multiplicity and intersection with examples.

***TEXTBOOKS / REFERENCES BOOKS***

*1. Robin Hartshorne, Algebraic Geometry, Graduate Texts in Mathematics (GTM) 8th Printing, Springer, 1997.*
*2. C. Musili, Algebraic Geometry for Beginners, Texts and Readings in Mathematics 20, Hindustan Book Agency, 2001.*

**18MAT632 ALGEBRAIC TOPOLOGY 3 0 0 3**

**Unit 1**

Geometric Complexes and Polyhedra: Introduction. Examples. Geometric Complexes and Polyhedra; Orientation of geometric complexes.

Simplicial Homology Groups: Chains, cycles, Boundaries and homology groups, Examples of homology groups; The structure of homology groups.

**Unit 2**

The Euler Poincare's Theorem; Pseudomanifolds and the homology groups of Sn. [Chapter 1 Sections 1.1 to 1.4 & Chapter 2 Sections 2.1 to 2.5 from the text].

**Unit 3**

Simplicial Approximation: Introduction; Simplicial approximation; Induced homomorphisms on the Homology groups; The Brouwer fixed point theorem and related results;

**Unit 4**

The Fundamental Group: Introduction; Homotopic Paths and the Fundamental Group; The Covering Homotopy Property for S1;

[Chapter 3 Sectins 3.1 to 3.4; Chapter 4 Sections 4.1 to 4.3]

**Unit 5**

Examples of Fundamental Groups; The Relation Between H1(K) and p1(iKi); Covering Spaces: The definition and some examples. Basic properties of covering spaces. Classification of covering spaces. Universal covering spaces. Applications.

[Chapter 4: Sections 4.4, 4.5; Chapter 5 Sections 5.1 to 5.5 from the text]

***TEXT BOOK***

*Fred H. Croom: Basic Concepts of Algebraic Topology, UTM, Springer, NY, 1978.*

***REFERENCES BOOKS:***


*1. Eilenberg S and Steenrod N: Foundations of Algebraic Topology, Princetion Univ. Press, 1952.*

*2. S.T. Hu: Homology Theory, Holden-Day, 1965.*

*3. S.T. Hu: Homology Theory, Academic Press, 1959.*


**18MAT634 CODING THEORY 3 0 0 3**

**Unit 1** Introduction to linear codes and error correcting codes. Encoding and decoding of a linear code,

**Unit 2** Dual codes. Hamming codes and perfect codes.

**Unit 3** Cyclic codes. Codes with Latin Squares, Introduction to BCH codes.

**Unit 4** Weight ennumerators and MDS codes.

**Unit 5** Linear coding theory problems and conclusions.

***TEXT BOOKS:***

*1. Raymond Hill, A first course in Coding Theory, Clarandon Press, Oxford (1986).*

*2. J.H. Van Lint, Introduction to Coding Theory, Springer (1998).*

***REFERENCES***

*1. W. Cary Huffman and Versa Pless, Fundamentals of Error Correcting Codes, Cambridge University Press (2003).*

*2. W.W. Peterson, Error Correcting Codes, Cambridge, MA MIT Press (1961).*

*3. V. Pless, W.C. Huffman and R.A. Brualdi, An Introduction to Algebraic Codes, in Hand book of coding theory, Eds. Amsterdam Elsevier (1998).*

**18MAT635 COMMUTATIVE ALGEBRA 3 0 0 3**

**Unit 1** Rings and ideals, modules and operations on them (tensor product, Hom, direct sum and product).

**Unit 2** Rings and modules of Fractions, primary decomposition.

**Unit 3** Integral dependence and Valuations, Chain Conditions.

**Unit 4** Noetherian Rings and Artin Rings.

**Unit 5** Discrete valuation Rings and Dedekind Domains, Dimension theory.

***TEXT BOOKS / REFERENCES***

*1. Atiyah-Macdonald, Commutative Algebra, Westview Press, 1994.*

*2. Zariski and Samuel, Commutative Algebra I, II , Springer, 1991.*

*3. Eisenbud, Commutative Algebra with a View Towards Algebraic Geometry, Springer, 1995.*

*4. Bourbaki, Commutative Algebra, Springer, 1989.*

**18MAT636 LIE ALGEBRA 3 0 0 3**

**Unit 1** Basic Concepts - Definition and Examples, Lie Algebra of Derivations, Adjoint Representation, Structure Constants, Direct Sums, Homomorphism and Isomorphisms, Ideals, Centre and Derived Algebra of a Lie Algebra, Simple Lie Algebras, The Normalizer of a Subalgebra and Centralizer of a Subset in Lie Algebras, Automorphism and Inner Automorphism of a Lie Algebra. (Book 1, Chapters 1 and 2).

**Unit 2** Descending Central Series of a Lie Algebra, Nilpotent Lie Algebras. Derived Series of a Lie Algebra, Radical of a Lie Algebra, Solvable Lie Algebras, Engel's Theorem. (Book 1, Chapter 3).

**Unit 3** Semisimple Lie Algebras - Theorems of Lie and Cartan, Jordan-Chevalley Decomposition, Cartan's Criterion. (Book 1, Chapter 4)

**Unit 4** Killing Form, Inner Derivations, Abstract Jordan Decomposition, Complete Reducibility of Lie algebras. (Book 1, Chapter 5)

**Unit 5** The Weyl Group, Root Systems. (Book 1, Chapter 10)

***TEXT BOOKS / REFERENCES BOOKS***

*1. Jacobson, Lie Algebras, Dover, 1979.*
*2. J.P. Serre, Lie Algebras and Lie Groups, Benjamin, 1965 (Translated from French).*
*3. J.E. Humphreys, Introduction to Lie Algebras and Representation Theory, Springer-Verlag, 1980.*

**18MAT637 THEORY OF MANIFOLDS 3 0 0 3**

**Unit 1**

Definition of Manifolds, Differentiable and Analytic Manifolds, Examples of Manifolds, Product of Manifolds, Mappings between Manifolds, Submanifolds, Tangent Vectors.

**Unit 2**

Differentials, The Differential of a Function, Infinitesimal Transformation, Tangent Space, Tangent Vector.

**Unit 3**

Cotangent Space, Vector Fields, Smooth Curve in a Manifold. Differential Forms– k-forms, Exterior Differential, its Existence and Uniqueness.

**Unit 4**

Exact Differential Forms. De Rham Cohomology Group, Betti Number, Poincare's Lemma, Inverse Function Theorem, Implicit Function Theorem and its Applications, Integral Curve of a Smooth Vector Field.

**Unit 5**

Orientable Manifolds– Definition and Examples. Smooth Partition of Unity– Definition and Existence. Riemannian Manifolds– Definition and Examples.

***TEXTBOOKS / REFERENCES:***

1. *P.M.Cohn, "Lie Groups", Cambridge University Press, 1965.*
2. *Claude Chevalley, "Theory of Lie Groups", Fifteenth Reprint, Princeton University Press, 1999.*

**18MAT638 Linear Algebra and its Applications 3 0 0 3**

**Unit 1** Review: Vector Spaces.
Inner Products, Angle and Orthogonality in Inner Product Spaces, Length of a Vector, Schwarz Inequality, Orthogonal Vectors, Orthogonal Complement, Orthogonal Bases: Gram-Schmidt Process. **(Sec. 4.4)**

**Unit 2** The Algebra of Linear Transformations, Characteristic Roots, Invertible Linear transformations, Characteristic Roots, Characteristic Vector, Minimal Polynomial, Matrices, Matrix of a Linear Transformation. **(Sec. 6.1 to 6.3).**

**Unit 3** Canonical Forms: Triangular, Nilpotent Transformations, Jordan and Rational Canonical Form, invariant subspaces, cyclic subspaces.
**(Sec. 6.4 to 6.6).**

**Unit 4** Trace and Transpose, Determinants, Symmetric and Skew Symmetric Matrices, Adjoint and Hermitian Adjoint of a Matrix, Hermitian, Unitary and Normal Transformations, Self Adjoint and Normal Transformations. **(Sec. 6.8 to 6.10)**

**Unit 5** Problems in Eigen Values and Eigen Vectors, Diagonalization, Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms, Conic Sections. **(Sec. 7.1 to 7.3 and 9.5 to 9.6 from Reference Book 2)**

***TEXT BOOK:***

*1. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.*

***REFERENCES:***

*1. David C. Lay, Linear Algebra and its Applications, Pearson.*
*2. Gilbert Strang,' Linear Algebra and its Applications, Fourth Edition, Cengage Learning, 2014.*
*3. Howard Anton and Chris Rorres, 'Elementary Linear Algebra', 9th Edition, Wiley, 2005.*
*4. Nabil Nassif, Jocelyne Erhel, Bernard Philippe, Introduction to Computational Linear Algebra, CRC press, 2015.*

**18MAT641 FIXED POINT THEORY 3 0 0 3**

**Unit 1** Contraction Principle, and its variants and applications;

**Unit 2** Fixed points of non-expansive maps and set valued maps, Brouwer-Schauder

fixed point theorems,

**Unit 3** Ky Fan Best Approximation Theorem, Principle and Applications of KKM - maps, their variants and applications.

**Unit 4** Fixed Point Theorems in partially ordered spaces and other abstract spaces.

**Unit 5** Application of fixed point theory to Game theory and Mathematical Economics.

***TEXTBOOKS / REFERENCES BOOKS***


1. *M.A. Khamsi and W.A. Kirk, An Introduction to Metric Spaces and Fixed Point Theory, Wiley - Inter Sci. (2001).*
2. *Sankatha Singh, Bruce Watson and Pramila Srivastava, Fixed Point Theory and Best Approximation: The KKM - map Principle, Kluwer Academic Publishers, 1997.*
3. *Kim C. Border, Fixed Point Theorems with Applications to Economics and Game Theory, Cambridge University Press, 1985.*


**18MAT642 FRACTALS 3 0 0 3**

**Unit 1** Classical Fractals, Self-similarity - Metric Spaces, Equivalent Spaces.

**Unit 2** The Space of Fractals, Transformation on Metric Spaces.

**Unit 3** Contraction Mapping and Construction of fractals from IFS.

**Unit 4** Fractal Dimension, Hausdorff measure and dimension, Fractal Interpolation Functions.

**Unit 5** Hidden Variable FIF, Fractal Splines, Fractal Surfaces, Measures on Fractals.

***TEXT BOOKS***


1. *M.F. Barnsley, Fractals Everywhere, Academic Press, 1993.*
2. *P.R. Massopust, Interpolation and Approximation with Splines and Fractals, Oxford University Press, 2009.*
3. *K. Falconer, Fractal Geometry (Mathematical Foundations and Applications), John Wiley & Sons, 2003.*


***REFERENCES***


*1. P.R. Massopust, Fractal Functions, Fractal Surfaces and Wavelets, Academic Press, 1994.*

*2. Heinz-Otto Peitgen and Peter Richter, The Beauty of Fractals, Springer, 1986.*

*3. Richard M. Crownover, Introduction to Chaos and Fractals, Jones and Bartlett Publishers, 1995.*

*4. Gerald A. Edgar, Measure, Topology and Fractal Geometry, Springer, 1990.*
*5. M.F. Barnsley, Superfractals, Academic Press, 2006.*
*6. B.B. Mandelbrot, The Fractal Geometry of Nature, Freeman, 1981.*

**18MAT643 HARMONIC ANALYSIS 3 0 0 3**

**Unit 1** Fourier series and integrals – Definitions and easy results – The Fourier transform – Convolution – Approximate identities – Fejer's theorem – Unicity theorem – Parselval relation – Fourier Stieltjes Coefficients – The classical kernels.

**Unit 2** Summability – Metric theorems – Pointwise summability – Positive definite sequences – Herglotz;s theorem – The inequality of Hausdorff and Young.

**Unit 3** The Fourier integral – Kernels on R. The Plancherel theorem – Another convergence theorem – Poisson summation formula – Bachner's theorem – Continuity theorem.

**Unit 4** Characters of discrete groups and compact groups – Bochners' theorem – Minkowski's theorem.

**Unit 5** Hardy spaces - Invariant subspaces – Factoring F and M. Rieza theorem – Theorems of Szego and Beuoling.

***TEXT BOOK:***
*Content and Treatment as in Henry Helson, Harmonic Analysis, Hindustan Book Agency, Chapters 1.1 to 1.9, 2.1 to 3.5 and 4.1 to 4.3*

**18MAT644 NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS 3 0 0 3**

Review of first order equations and characteristics.
**Unit 1** Weak solutions to hyperbolic equations - discontinuous solutions, shock formation, a formal approach to weak solutions, asymptotic behaviour of shocks.

**Unit 2** Diffusion Processes - Similarity methods, Fisher's equation, Burgers' equation, asymptotic solutions to Burgers' equations.

**Unit 3** Reaction diffusion equations - traveling wave solutions, existence of solutions, maximum principles and comparison theorem, asymptotic behaviour.

**Unit 4** Elliptic equations - Basic results for elliptic operators, eigenvalue problems,

stability and bifurcation.

**Unit 5** Hyperbolic system.

***TEXT BOOK***

*J David Logan, An Introduction to Nonlinear Partial Differential Equations, John Wiley and Sons, Inc., 1994*

**18MAT645 WAVELETS ANALYSIS 3 0 0 3**

**Unit 1** Basic Properties of the Discrete Fourier Transform, Translation - Invariant Linear Transformations. The Fast Fourier Transform.

**Unit 2** Construction of Wavelets on $Z_N$, The First Stage Construction of Wavelets on $Z_N$, The Iteration Step"s. Examples and Applications, $l2(Z)$

**Unit 3** Complete Orthonormal Sets in Hilbert Spaces, $L_2([-\pi,\pi))$ and Fourier Series, The Fourier Transform and Convolution on $l_2(Z)$, First-Stage Wavelets on $Z$
The Iteration Step for Wavelets on Z , Implementation and Examples.

**Unit 4** $L_2(R)$ and Approximate Identities, The Fourier Transform on $R$, Multiresolution Analysis and Wavelets,

**Unit 5** Construction of Multiresolution Analyses, Wavelets with Compact Support and Their Computation.

***TEXT BOOK:***

*Michael W. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer, 1999.*

***REFERENCES:***


1. *Daubechis, Ten Lectures on Wavelets, SIAM, 1992.*
2. *S. Mallat, A Wavelet Tour of Signal Processing, Elsevier, 2008.*


**18MAT646 MATHEMATICAL PHYSICS 3 0 0 3**

***Objective**: This course intends to introduce applications of various mathematical techniques to problems of Theoretical Physics. Examples could be chosen from all 4 traditional divisions of Modern Fundamental Theoretical Physics – Classical Mechanics, Electrodynamics, Quantum Mechanics and Statistical Physics.*

**Unit 1**

Vector calculus and applications in electromagnetic theory and fluid mechanics.

**Unit 2**
Introduction to tensor calculus: review of basics, index notation, tensors in physics and geometry, Levi-Civita tensor, transformations of vectors, tensors and vector fields, covariance of laws of physics.

**Unit 3**
Calculus of variations and extremal problems, Lagrange multipliers to treat constraints, Introduction to the Lagrangian and Hamiltonian formulations of classical mechanics with applications.

**Unit 4**
Gamma and Beta functions, Dirac delta function, Special functions, Review of Legendre, Bessel functions and spherical harmonics (with applications to Quantum mechanics), series solutions, generating functions, orthogonality and completeness,

**Unit 5**
Applied linear algebra: Dirac notation, dual vectors, projection operators, symmetric hermitian, orthogonal and unitary matrices in physics, diagonalization, orthogonality and completeness of eigenvectors, spectral decomposition and representation, simultaneous diagonalization, normal matrices, applications to coupled vibrations, Schrodinger equation in matrix form.

***TEXT BOOKS:***


1. *Arften and Weber, Mathematical Methods for Physics, Elsevier, 6$^{th}$ Ed., 2005.*
2. *Riley, Hobson and Bence, Mathematical Methods for Physics and Engineering, Cup, 3$^{rd}$ Edition, 2010.*


**18MAT651 QUEUING THEORY AND INVENTORY CONTROL THEORY 3 0 0 3**

**Unit 1** Inventory concept – Components of Inventory model.

**Unit 2** Deterministic Continuous Review model - Deterministic Periodic Review model.

**Unit 3** The classical EOQ – Non zero lead time – EOQ with shortages allowed.

**Unit 4** Deterministic Multiechelon Inventory models for supply chain management.

**Unit 5**
A stochastic continuous review model – A stochastic single period model for perishable products.

***TEXT BOOKS***

*1. F S Hillier and Gerald J Lieberman, Introduction to Operations research, 8th edition, McGraw Hill.*

*2. Ravindran, Phillips and Solberg, Operations research Principles and Practice, 2nd Edition, John Wiley & Sons.*

**18MAT653 STATISTICAL PATTERN CLASSIFICATIONS 3 0 0 3**

**Unit 1 Introduction and Bayesian Decision Theory**

Introduction – Pattern recognition systems – the design cycle – learning and adaptation – Bayesian decision theory – continuous features – Minimum error rate classification – discriminant functions and decision surfaces – the normal density based discriminant functions.

**Unit 2 Maximum-likelihood and Bayesian Parameter Estimation**

Maximum likelihood estimation – Bayesian estimation - Bayesian parameter estimation – Gaussian case and general theory – problems of dimensionality – components analysis and discriminants – hidden Markov models.

**Unit 3 Nonparametric Techniques and Linear Discriminant Functions**

Nonparametric techniques – density estimation – Parzen windows – nearest neighborhood estimation – rules and metrics – linear discriminant functions and decision surfaces – generalized linear discriminant functions – two-category linearly separable case – minimizing the perception criterion function.

**Unit 4 Nonmetric methods and Algorithm-independent Machine Learning**

Nonmetric methods – decision trees – CART methods – algorithm-independent machine learning – lack of inherent superiority of any classifier – bias and variance for regression and classification – resampling or estimating statistics – estimating and comparing classifiers.

**Unit 5 Unsupervised Learning and Clustering**

Unsupervised learning and clustering – mixture densities and identifiability – maximum likelihood estimates – application to normal mixtures – unsupervised Bayesian learning – data description and clustering – criterion functions for clustering – hierarchical clustering – component analysis – low-dimensional representations and multi-dimensional scaling.

***TEXT AND REFERENCE BOOKS:***

*1. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern Classification, Second Edition, 2003, John Wily & Sons.*

*2. Earl Gose, Richard Johnson baugh and Steve Jost, Pattern Recognition and Image Analysis, 2002, Prentice Hall of India.*

**18MAT654 STATISTICAL QUALITY CONTROL AND SIX SIGMA QUALITY ANALYSIS 3 0 0 3**

**Unit 1** Introduction to Quality Management – Japanese System of Total Quality Management.

**Unit 2** Quality Circles - 7 Quality Control tools - 7 New Quality Control tools.

**Unit 3** ISO 9000 Quality system Standards - Project Planning, Process and measurement system capability analysis - Area properties of Normal distribution.

**Unit 4** Metrics of Six sigma, The DMAIC cycle - Design for Six Sigma - Lean Sigma – Statistical tools for Six Sigma.

**Unit 5** Taguchi methods. Loss functions and orthogonal arrays and experiments.

***TEXT AND REFERENCE BOOKS***

*1. Ravichandran. J, Probability and Statistics for Engineers, 1st Edition 2012 (Reprint), Wiley India.*

*2. Montgomery Douglas C., Introduction to Statistical Quality Control, Sixth Edition. John Wiley & Sons, (2008).*

*3. Ishikawa K., Guide to Quality Control, 2nd Edition: Asian Productivity Organization, Tokyo (1983).*

*4. Taguchi G, Introduction to Quality Engineering: Designing Quality into Products and Processes Second Edition. (1991).*

*5. Harry, M and Schroeder R., Six Sigma: The Breakthrough Management Strategy. Currency Publishers, USA. (2000).*

**18MAT655 THEORY OF SAMPLING AND DESIGNS OF EXPERIMENTS 3 0 0 3**

**Unit 1**

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and srs. Systematic sampling. Comparison of systematic sampling - srs and stratified random sampling for a population with a linear trend.

**Unit 2**

Unbiased ratio type estimators - Hartly-Ross estimator, regression method of estimation. Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two-stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error.

**Unit 3**

Unequal probability sampling, PPS sampling with and without replacement, cumulative total method, Lahiris method, Midzuno-Zen method, estimation of the population total and its estimated variance under PPS wr sampling, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator.

**Unit 4**

Elementary concepts (one and 2 way classified data) Review of elementary design (CRD, RBD, LSD) Missing plot technique in RBD and LSD with one and two missing values, Gauss-Markov theorem, BIBD: Elementary parametric relations, Analysis, PBIBD.

**Unit 5**

General factorial experiments, factorial effects, best estimates and testing the significance of factorial effects, study of $2^3$ and $2^4$ factorial experiments.

***TEXT AND REFERENCE BOOKS***

*1. Cochran, W.C. Sampling Techniques, Third Edition, Wiley Eastern, (1977).*
*2. Des Raj, Sampling Theory, Tata McGraw Hill, New Delhi, (1976).*
*3. Murthy, M.N., Sampling Theory, Tata McGraw Hill, New Delhi, (1967).*

**18MAT656 TIME SERIES ANALYSIS 3 0 0 3**

**Unit 1** Time series, components of time series, additive and multiplicative models, determination of trend, analysis of seasonal fluctuations.

**Unit 2** Test for trend and seasonality, exponential and moving average smoothing, holt-winter smoothing, forecasting based on smoothing.

**Unit 3** Time series as a discrete parameter stochastic process, auto covariance and auto correlation functions and their properties, stationary processes, test for stationarity, unit root test, stationary processes in the frequency domain, spectral analysis of time series.

**Unit 4** Detailed study of the stationary processes: moving average (MA), autoregressive (AR), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.

**Unit 5** Estimation of ARMA models, maximum likelihood method (the likelihood function for a Gaussian AR(1) and a Gaussian MA(1)) and Least squares, Yule-Walker estimation for AR Processes, choice of AR and MA periods, forecasting, residual analysis and diagnostic checking.

***TEXT BOOKS***

*1. Anderson, T.W. The Statistical Analysis of Time Series, John Wiley, New York, 1971.*
*2. Box, G.E.P. and Jenkins, G.M. Time Series Analysis- Forecasting and Control, Holden-day, San Francisco,1976.*
*3. Kendall, Sir Maurice and Ord, J.K., Time Series, Edward Arnold, London, 1990.*

**18MAT657 STATISTICAL TECHNIQUES FOR DATA ANALYTICS 3-0-0-3**

Data Collection, classification and analysis - Sampling methods, classification of data and representation of data- bar and pie charts – histogram frequency polygon - Data Analysis Measures of Central tendency and dispersion - Mean, median, mode, absolute, quartile and standard deviations, skewness and kurtosis for both grouped and ungrouped data. Association of attributes.

Curve fitting and interpolation - Fitting of straight lines and curves - Correlation, regression, fitting of simple linear lines, polynomials and logarithmic functions - Interpolation and extrapolation methods - Binomial expansion, Newton and Gauss methods.

Index numbers and time series analysis - Types of index numbers, construction of index numbers such as simple aggregate, weighted aggregate index numbers, chain index numbers and consumer price indices - Time series and its components and computation of trends and variations - Seasonal variations - Trend analysis methods.

Decision analysis and Game theory - Payoffs, regrets, maximin and minimax criteria and loss and risks – Games – payoff matrix, saddle point, value of game and methods of solving – two-person-zero-sum games, dominance method, sub-game method

***Text Books:***

1. *Pillai R.S. N. andBagavathi. "Statistics", S. Chand, New Delhi, 2001.*
2. *Kanti Swarup, Gupta, P.K., and Man Mohan. "Operations Research" (Chapters 16 and 17), S. Chand, New Delhi, 2001.*

***References Book***

*1. Amir D Aczel, Jayavel Soundarapandian , Palanisamy Saravanan, Rohit Joshi, Complete Business Statistics,7edition,McGraw Hill, New Delhi*

**18MAT661 ADVANCED BOUNDARY LAYER THEORY 3 0 0 3**

**Unit 1**

Introduction – limitations of ideal fluid dynamics – Importance of Prandtl's boundary layer theory - boundary layer equations in two dimensional flows – boundary layer flow over a flat plate – Blasius solution – Boundary layer over a wedge.

**Unit 2**

Energy integral equation for two-dimensional laminar boundary layers in incompressible flow – application of Von Karman's integral equations to boundary layer with pressure gradient.

**Unit 3**

Displacement, momentum, energy thickness – axially symmetric flows – momentum equation for laminar boundary layer by von Karman – Wall shear and drag force on a flat plate due to boundary layer – coefficient of drag. Boundary layer equations for a 2D viscous incompressible fluid over a plane wall – Similar solutions – Separation of boundary layer flow.

**Unit 4**

Hydromagnetic Boundary layers – Hartman Layer – MHD Blasius flow. Thermal boundary layers – thermal boundary layer equation in two dimensional flow – Thermal boundary layers with and without coupling of velocity and temperature field – forced convection in a laminar boundary on a flat plate.

**Unit 5**

Polhausen's method of exact solution for the velocity and thermal boundary layers in free convection from a heated plate – thermal energy integral equation. Boundary layer control using suction and injection.

***TEXT BOOKS / REFERENCES:***

*1. H.Schlichting and K.Gersten, "Boundary Layer Theory", Eighth Edition, Springer, 2000.*

*2. L. Rosenhead, "Laminar Boundary Layers", Dover, 1988.*

*3. G.K.Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press,1993.*

*4. P.H.Roberts , "An Introduction to MHD" , Longmans, 1967.*

**18MAT662 COMPUTATIONAL FLUID DYNAMICS 3 0 0 3**

**Unit 1** Review of Conservation equations for mass, momentum and energy; coordinate systems; Eulerian and Lagrangian approach, Conservative and non-conservative forms of the equations, rotating co-ordinates.

**Unit 2** Classification of system of PDEs: parabolic elliptic and hyperbolic; Boundary and initial conditions; Overview of numerical methods; Review of Finite Difference Method, Introduction to integral method, method of weighted residuals, finite elements finite volume method & least square method.

**Unit 3** Numerical Grid Generation: Basic ideas, transformation and mapping, unstructured grid generation, moving grids, unmatched meshes. Finite Volume Method: Basic methodology, finite volume discretization, approximation of surface and volume integrals, interpolation methods - central, upwind and hybrid formulations and comparison for convection-diffusion problem; Basic computational methods for compressible flows.

**Unit 4** Advanced Finite Volume methods: FV discretization in two and three dimensions, SIMPLE algorithm and flow field calculations, variants of SIMPLE, Turbulence and turbulence modelling, illustrative flow computations.

**Unit 5** Introduction to turbulence modelling, CFD methods for compressible flows.

***TEXT BOOKS / REFERENCE BOOKS:***

*1. Anderson D A, Tannehill J C, and Pletcher R H, Computational Fluid Mechanics and Heat Transfer, 2nd edition, Taylor & Francis, 1997.*
*2. Ferziger, J. H. and Peric, M., Computational Methods for Fluid Dynamics, 3rd edition, Springer. 2003.*

**18MAT663 FINITE ELEMENT METHOD 3 0 0 3**

**Unit 1** Finite Element Method: Variational formulation - Rayleigh-Ritz minimization - weighted residuals - Galerkin method applied to boundary value problems.

**Unit 2** Global and local finite element models in one dimension - derivation of finite element equation.

**Unit 3** Finite element interpolation - polynomial elements in one dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite elements for rectangular elements - global interpolation functions.

**Unit 4** Local and global forms of finite element equations - boundary conditions - methods of solution for a steady state problem - Newton-Raphson continuation.

**Unit 5** One dimensional heat and wave equations.

***TEXT AND REFERENCE BOOKS***


1. *J.N .Reddy, An Introduction to the Finite Element Method, McGraw Hill, NY.*
2. *Chung, Finite Element Analysis in Fluid Dynamics, McGraw Hill Inc.*


**18MAT664 MAGNETO-HYDRO DYNAMICS 3 0 0 3**

**Unit 1**

Electromagnetic field equations – Maxwell's equations - Electromagnetic effects and the magnetic Reynolds number – induction equation. Alfven's Theorem – Ferraro's Law of irrotation – Electromagnetic stresses.

**Unit 2**

Magnetohydrostatics and steady states – Hydromagnetic equilibria and Force free magnetic fields —Chandrasekhar's theorem – General solution of force free magnetic field when**Error! Objects cannot be created from editing field codes.** is constant – Some examples of force free fields.

**Unit 3**

Steady laminar motion – Hartmann flow. Tensor electrical conductivity, Hall current and ion slip – simple flow problems with tensor electrical conductivity.

**Unit 4**

Magnetohydrodynamic waves - Alfven waves – Stability of hydromagnetic systems - Normal mode analysis - Squire's theorem – Orr-Sommerfield equation – Instability of linear pinch – Flute instability – A general criterion for stability.

**Unit 5** Bernstein's method of small oscillations – Jeans Criterion for Gravitational stability – Chandrasekhar's generalization for MHD and rotating fluids.

***TEXT BOOKS / REFERENCES:***


*1. Ferraro, V.C.A and Plumpton, C., "An Introduction to Magneto-Fluid Mechanics", Clarendon Press, Oxford, 1966.*

*2. M.R. Crammer, and Shi-I Pai, "Magneto-Fluid Dynamics for Engineers and Applied Physicists", Scripta Publishing Company, Washington, 1973.*

*3. P.H. Roberts, "An Introduction to Magnetohydrodynamics", Longmans, Green and Co, London, 1967.*

*4.S. Chandrasekhar, "Hydrodynamic and Hydromagnetic Stability", Dover Publications, 1981.*


**18MAT665 MATHEMATICAL FOUNDATIONS OF INCOMPRESSIBLE FLUID FLOW 3 0 0 3**

**Unit 1** Kinematics of Fluids in motion – Lagrangian and Eulerian methods – Equation of continuity – Boundary conditions – Kinematic and physical – steam line, path line and streak line – velocity potential – vorticity - rotational and irrotational motion.

**Unit 2** Equation of Motion of Compressible Viscous Fluid (Navier-Stokes Equations) - General Properties – Equation of motion of inviscid fluid – Euler's equation – impulsive force – physical meaning of velocity potential - energy equation.
**Unit 3** Lagrange's hydrodynamical equations - Bernoulli's equation and its applications - Motion in two-dimensions and sources and sinks – irrotational motion – complex potential - Milne-Thomson circle theorem – Blasius theorem.

**Unit 4** General theory of irrotational motion – flow and circulation – Stoke's theorem – Kelvin's Circulation theorem – Permanence of irrotational motion - Kelvin's minimum energy theorem - Viscous Incompressible flow - Dimensional Analysis – Buckingam**Error! Objects cannot be created from editing field codes.** theorem.

**Unit 5** Exact Solutions of Navier Stokes Equations – Small Reynold's number flows – flow past a sphere – Stokes flow – Whitehead's paradox - Flow past a circular cylinder – Stoke's Paradox.

***TEXT BOOKS / REFERENCES:***

*1. G.K. Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press, 1997.*
*2. L.M. Milne-Thompson, "Theoretical Hydrodynamics", Dover Publications, 1968.*
*3. Victor L. Streeter and E. Benjamin Wylie, "Fluid Mechanics", Mc Graw Hill, 1983.*
*4. S.W. Yuan, "Foundations of Fluid Mechanics", Prentice Hall, New Jersey, 1970.*

**18MAT666 Introduction to FLUID DYNAMICS 3 0 0 3**

**Unit 1 Basic Concepts and Properties**

Fluid – definition, distinction between solid and fluid - Units and dimensions – Properties of fluids – density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillary and surface tension – Fluid statics: concept of fluid static pressure, absolute and gauge pressures – pressure measurements by manometers and pressure gauges.

**Unit 2 Fluid Kinematics**

Fluid Kinematics - Flow visualization - lines of flow - types of flow - velocity field and acceleration - continuity equation (one and three dimensional differential forms)- Equation of streamline - stream function - velocity potential function - circulation - flow net –

**Unit 3 Fluid Dynamics**

Fluid dynamics - equations of motion - Euler's equation along a streamline - Bernoulli's equation – applications - Venturi meter, Orifice meter, Pitot tube -

dimensional analysis - Buckingham's theorem - applications - similarity laws and models.

**Unit 4 Incompressible Fluid Flow**

Viscous flow - Navier - Stoke's equation (Statement only) - Shear stress, pressure gradient relationship - laminar flow between parallel plates - Laminar flow through circular tubes (Hagen poiseulle's).

**Unit 5**

Hydraulic and energy gradient - flow through pipes - Darcy-weisback's equation - pipe roughness - friction factor - Moody's diagram - minor losses - flow through pipes in series and in parallel - power transmission - Boundary layer flows, boundary layer thickness, boundary layer separation - drag and lift coefficients.

***TEXT BOOKS***

*1. Streeter, V.L., and Wylie, E.B., Fluid Mechanics, McGraw-Hill, 1983.*

*2. Kumar, K.L., Engineering Fluid Mechanics, Eurasia Publishing House (P) Ltd., New Delhi (7th Edition), 1995.*

***REFERENCE:***

*White, F.M., Fluid Mechanics, Tata McGraw-Hill, 5th Edition, New Delhi, 2003.*

**18MAT671 DATA STRUCTURES AND ALGORITHMS 3 0 0 3**

*(Pre-requisite: Data Structures and Algorithms.*

**Unit 1** Introduction: growth functions – recurrence relation – methods – master method. Sorting: bubble – insertion sort – selection sort.

**Unit 2** Divide and conquer: quick sort – merge sort – bucket sort – lower bounds – heap sort – comparisons of sorting.

**Unit 3** Greedy algorithm: fractional knapsack problem – task scheduling problem. Dynamic programming: matrix multiplication problem – 0-1 knapsack.

**Unit 4** Graph algorithms: graph traversal (DFS, BFS with analysis) – biconnected components – strong connectivity; shortest path algorithms (along with analysis) – Dijkstra – Bellman Ford – Floyd Warshall. All pairs shortest path algorithm – minimum spanning tree (with analysis) – Kruskal – Prim's – Baruvka's.

**Unit 5**

NP problems: definition, P, NP, NP complete, NP hard & co-NP, examples – P, NP.

***TEXT BOOK***

*Goodrich M T and Tamassia R, Algorithm Design Foundations, Analysis, and Internet Examples, John Wiley and Sons, 2002.*

***REFERENCES***

*1. Baase S and Gelder A V, ``Computer Algorithms – Introduction to Design and Analysis, Pearson Education Asia, 2002.*

*2. Cormen T H, Leiserson C E, Rivest R L and Stein C, Introduction to Algorithms, Prentice Hall of India Private Limited, 2001.*

*3. Dasgupta S, Papadimitriou C and Vazirani U, Algorithms, Tata McGraw-Hill, 2009.*

*4. Horowitz E, Sahni S and Rajasekaran S, Fundamentals of Computer Algorithms, Galgotia, 1998.*

**18MAT672 ALGORITHMS FOR ADVANCED COMPUTING 3-0-0-3**

**Unit I** Issues regarding classification and prediction, Bayesian Classification, Classification by back propagation, Classification based on concepts from association rule mining, Other Classification Methods, Classification accuracy.

**Unit II** Introduction to Decision trees - Classification by decision tree induction – Various types of pruning methods – Comparison of pruning methods – Issues in decision trees – Decision Tree Inducers – Decision Tree extensions.

**Unit III** Introduction, Core text mining operations, Preprocessing techniques, Categorization, Clustering, Information extraction, Probabilistic models for information extraction

**Unit IV** Soft Computing: Rationale, motivations, needs, basics: examples of applications in diverse fields, Basic tools of soft computing: Neural Networks, Fuzzy Logic Systems, and Support Vector Machines, Statistical Approaches to Regression and Classification - Risk Minimization, Support Vector Machine Algorithms.

**Unit V** Single-Layer Networks: The Perceptron, The Adaptive Linear Neuron (Adaline) and the Least Mean Square Algorithm - Multilayer Perceptrons: The Error Backpropagation Algorithm – The Generalized Delta Rule, Heuristics or Practical Aspects of the Error Backpropagation Algorithm.

***Text Books:***

1. *Jiawei Han and Micheline Kamber, "Data Mining: Concepts and Techniques", Morgan Kaufmann Publishers, 3rd ed, 2010.*
2. *Jared Dean, "Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners", Wiley India Private Limited, 2014.*

***References Books :***

1. *LiorRokach and Oded Maimon, "Data Mining and Knowledge Discovery Handbook", Springer, 2nd edition, 2010.*
2. *Ronen Feldman and James Sanger, "The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data", Cambridge University Press, 2006.*
3. *Vojislav Kecman, "Learning and Soft Computing", MIT Press, 2010*.

**18MAT673 COMPUTER AIDED DESIGN OF VLSI CIRCUITS 3 0 0 3**

**Unit 1**

Introduction of Design Methodologies and Graph Theory: The VLSI Design Problems - Design Methods – Design Cycle – Physical Design Cycle - Design Styles.

**Unit 2**

Algorithmic and System Design - Structural and Logic Design - Layout Design. Graph terminologies – Data structures for the representation of Graphs – Algorithms: DFS – BFS - Dijkstra's shortest path algorithm – Prim's algorithm for minimum spanning trees. Combinatorial Optimization Problems – Complexity Class – P - NP Completeness and NP Hardness problems.

**Unit 3**

Placement, Partitioning and Floor Planning: Types of Placement Problems – Placement Algorithms – K-L Partitioning Algorithm. Optimization Problems in Floor planning - Shape Function and Floor plan Sizing.

**Unit 4**

Routing and Compaction: Types of Routing Problems – Area Routing – Channel Routing – Global Routings.

**Unit 5** 1D and 2D Compaction. Gete level – Switch level Modeling and Simulations.

***TEXT BOOK / REFERENCES:***

1. *Gerez, "Algorithms for VLSI Design Automation", John Wiley & Sons, 2000.*
2. *Naveed Sherwani, "Algorithms for VLSI Physical Design Automation", Second Edition, Kluwer Academic Publishers, 1995.*
3. *Sadiq M Sait and Habib Youssef, "VLSI Physical Design Automation: Theory and Practice", IEET, 1999.*
4. *M. Sarrafzadeh and C. K. Wong, An Introduction to VLSI Physical Design, McGraw- Hill, New York, NY, 1996.*
5. *Giovanni De Micheli, Synthesis and Optimization of Digital Circuits, Tata McGraw Hill, 1994*

**18MAT674 CRYPTOGRAPHY 3 0 0 3**

**Unit 1 Classical ciphers:** Cryptanalysis of classical ciphers, Probability theory, Perfect security.
**Block ciphers:** DES, AES, Block cipher modes of operation.

**Unit 2 Private-key encryption:** Chosen plaintext attacks, Randomised encryption, Pseudorandomness, Chosen cyphertext attacks.

**Unit 3 Message authentication codes:** Private-key authentication, CBC-MAC, Pseudorandom functions, CCA-secure private-key encryption.

**Unit 4 Hash function:** Integrity, Pre-image resistance, 2nd pre-image resistance, Collision freeness.
**Key distribution:** Key distribution centres, Modular arithmetic and group theory, Diffie-Hellman key exchange.

**Unit 5 Public-key Distribution:** EIGamal encryption, Cramer-Shoup encryption, Discrete logarithm problem.
**Digital Signatures:** RSA signatures, RSA-FDH and RSA-PSS signatures, DSA signatures.

***TEXT / REFERENCE BOOKS:***

*1. Katz and Lindell, Introduction to Modern Cryptography. Second Edition, Chapman & Hall/ CRC Press, 2014.*
*2. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press.*
*3. Hans Delfs, Helmut Knebl, "Introduction to Cryptography, Principles and Applications", Springer Verlag.*

**18MAT675 FUZZY SETS AND ITS APPLICATIONS 3 0 0 3**

**Unit 1 Fuzzy Sets**
Crisp Sets - an Overview, Fuzzy Sets - Definition and Examples, $\alpha$ - Cuts and its Properties, Representations of Fuzzy Sets, Extension Principles of Fuzzy Sets, Operations on Fuzzy Sets - Fuzzy Complements, Fuzzy Intersections, Fuzzy Unions, Combinations of Operations, Aggregation Operations.

**Unit 2 Fuzzy Arithmetic**
Fuzzy Numbers, Arithmetic Operations on Intervals, Arithmetic Operations on Fuzzy Numbers.

**Unit 3 Fuzzy Relations**
Binary Fuzzy relations, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations.

**Unit 4 Fuzzy Logic**

Classical Logic, Multivalued Logic, Fuzzy Propositions, Fuzzy Quantifiers, Linguistic Hedges, Inference from Conditional Fuzzy Propositions, Conditional and Qualified Propositions and Quantified Propositions.

**Unit 5 Uncertainty-based Information**

Information and Uncertainty, Non Specificity of Crisp Sets – Non Specificity of Fuzzy Sets, Fuzziness of Fuzzy Sets, Uncertainty In Evidence Theory, Principles of Uncertainty.

***TEXT AND REFERENCE BOOKS:***


*1. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic- Theory and Applications, Prentice Hall of India, 1997.*

*2. Timothy J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill, 1997.*

*3. H.J. Zimmermann, Fuzzy Sets and its Applications, Allied publishers, 1991.*


**18MAT676 INTRODUCTION TO SOFT COMPUTING 3 0 0 3**

**Unit 1 Soft Computing**

Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing.

**Unit 2 Artificial Intelligence**

Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies.

**Unit 3 Fuzzy Logic**

Crisp set and Fuzzy set, basic concepts of fuzzy sets, membership functions. Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations. Propositional logic and Predicate logic, fuzzy If - Then rules, fuzzy mapping rules and fuzzy implication functions, Applications.

**Unit 4 Neural Networks**

Basic concepts of neural networks, Neural network architectures, Learning methods, Architecture of a back propagation network, Applications.

**Unit 5 Genetic Algorithms**

Basic concepts of genetic algorithms, encoding, genetic modeling.

**Hybrid Systems:** Integration of neural networks, fuzzy logic and genetic algorithms.

***TEXT AND REFERENCE BOOKS***

*1. S. Rajasekaran and G. A. Vijaylakshmi Pai. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.*
*2. K. H. Lee. First Course on Fuzzy Theory and Applications, Springer-Verlag.*
*3. J. Yen and R. Langari. Fuzzy Logic, Intelligence, Control and Information, Pearson Education.*

**18MAT677 OBJECT- ORIENTED PROGRAMMING AND PYTHON 3 0 0 3**

**Unit 1** Object-oriented programming concepts – objects – classes – methods and messages – abstraction and encapsulation – inheritance – abstract classes – polymorphism.

Introduction to C++ – classes – access specifiers – function and data members – default arguments – function overloading – friend functions – const and volatile functions - static members – Objects - pointers and objects – constant objects – nested classes – local classes.

**Unit 2** Constructors – default constructor – Parameterized constructors – Constructor with dynamic allocation – copy constructor –destructors – operator overloading – overloading through friend functions – overloading the assignment operator – type conversion – explicit constructor.

**Unit 3** Function and class templates - Exception handling try-catch-throw paradigm – exception specification – terminate and Unexpected functions – Uncaught exception.

**Unit 4** Inheritance – public, private, and protected derivations – multiple inheritance - virtual base class – abstract class – composite objects Runtime polymorphism – virtual functions – pure virtual functions – RTTI – typeid – dynamic casting – RTTI and templates – cross casting – down casting.

**Unit 5** Python Programming.

***TEXT BOOK***

*1. B. Trivedi, "Programming with ANSI C++", Oxford University Press, 2007.*

***REFERENCES BOOKS***

*1. Ira Pohl, "Object Oriented Programming using C++", Pearson Education, Second Edition Reprint 2004.*
*2. S. B. Lippman, Josee Lajoie, Barbara E. Moo, "C++ Primer", Fourth Edition, Pearson Education, 2005.*
*3. B. Stroustrup, "The C++ Programming language", Third edition, Pearson Education, 2004.*

**18MAT696 DISSERTATION 10 cr**

Every student is required to register for a project under a faculty member, within or outside the Department. At the completion of the Project work, the student will submit a bound volume of the project report in the prescribed format. The project work will be evaluated by a team of duly appointed examiners. The evaluation is based on contents, presentation and viva-voce.