DEPARTMENT OF MATHEMATICS
SCHOOL OF MATHEMATICAL SCIENCES
NORTH MAHARASHTRA UNIVERSITY
JALGAON, INDIA

SYLLABUS STRUCTURE
FOR

M. Sc. (Mathematics)
With specialization in Computational Mathematics

WITH EFFECT FROM ACADEMIC

YEAR 2011-2012

Department of Mathematics
School of Mathematical Sciences
North Maharashtra University, Jalgaon

Syllabus for M.Sc. (Mathematics) with specialization in Computational Mathematics
Syllabus Structure

Semester-I

Course Code	Title of the Course	Contact hours/week			Distribution of Marks for Examination					
					Internal		External		Total	
		Th (L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr
MT-101	Real Analysis	04	--	04	40	--	60	--	100	--
MT-102	Topology	04	--	04	40	--	60	--	100	--
MT-103	Discrete Mathematics	04	--	04	40	--	60	--	100	--
MT-104	Abstract Algebra	04	--	04	40	--	60	--	100	--
MT-105	Lab Course	04	06	10	--	40	--	60	--	100

Semester-II

Course Code	Title of the Course	Contact hours / week			Distribution of Marks for Examination					
					Internal		External		Total	
		Th (L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr
MT-201	Complex Analysis	04	--	04	40	--	60	--	100	--
MT-202	Measure and Integration Theory	04	--	04	40	--	60	--	100	--
MT-203	Differential Equations	04	--	04	40	--	60	--	100	--
MT-204	Advanced Abstract Algebra	04	--	04	40	--	60	--	100	--
MT-205	Lab Course	04	06	10	--	40	--	60	--	100

Semester-III

Course Code	Title of the Course	Contact hours / week			Distribution of Marks for Examination					
					Internal		External		Total	
		Th (L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr
MT-301	Functional Analysis	04	--	04	40	--	60	--	100	--
MT-302	Partial Differential Equations	04	--	04	40	--	60	--	100	--
MT-303	Optional Course	04	--	04	40	--	60	--	100	--
MT-304	Optional Course	04	--	04	40	--	60	--	100	--
MT-305	Lab Course	04	06	10	--	40	--	60	--	100

Semester-IV

Course Code	Title of the Course	Contact hours / week			Distribution of Marks for Examination					
					Internal		External		Total	
		Th (L)	Pr	Total	Th	Pr	Th	Pr	Th	Pr
MT-401	Analytical Number Theory	04	--	04	40	--	60	--	100	--
MT-402	Transform Theory	04	--	04	40	--	60	--	100	--
MT-403	Optional Course	04	--	04	40	--	60	--	100	--
MT-404	Optional Course	04	--	04	40	--	60	--	100	--
MT-405	Lab Course	04	06	10	--	40	--	60	--	100

Th: Theory **Pr:** Practicals/Project **L:** Lectures

List of optional courses to be offered in Semester-III

MT-303(A): Classical Mechanics
MT-303(B): Commutative Algebra
MT-303(C): Special Functions

Please note that students have to choose any one course from the above list as an optional course MT-303.

MT-304(A): Operation Research
MT-304(B): Stability Theory
MT-304(C): Financial Mathematics

Please note that students have to choose any one course from the above list as an optional course MT-304.

List of optional courses to be offered in Semester-IV

MT-403(A): Fluid Dynamics
MT-403(B): Linear Integral Equations
MT-403(C): Difference Equations

Please note that students have to choose any one course from the above list as an optional course MT-403.

MT-404(A): Fuzzy Sets and Applications
MT-404(B): Non Commutative Rings
MT-404(C): Actuarial Mathematics

Please note that students have to choose any one course from the above list as an optional course MT-404.

Examination Pattern:

There would be continuous internal assessment (CIA) and end of term examination (ETE) for each course. CIA includes examinations, assignments, viva-voce examinations and presentations.

Number of Internal Tests and Time duration:

Concern teacher in consultation with Head of the Department may conduct 2 or 3 tests of 40 marks with time duration 2 hours for internal examination of all theory and practical courses. Head of the department will declare detailed Time-Table well in advance.

External Examination:

Department will conduct external examinations at the end of each semester. Each course will have examination of 60 marks of duration 3 hours. Head of the Department will declare detailed Time-Table for external examinations well in advance.

Standard of Passing:

To pass any course, the candidate has to secure at least 40% marks in total with internal and external examinations for each course provided that candidate has to secure at least 24 marks out of 60 in external examination of each course. The student failed in external examination shall have to appear for subsequent external examination for that course.

Award of class/Grade: As per the University's common rules of CGPA system.

Declaration of results: By Controller of Examinations, N. M. U., Jalgaon.

Verification or revaluation: As per University's rules.

MT-101: - Real Analysis

Unit I: The Riemann-Stieltjes Integral

Definition and Existence of the integral, Properties of integral, Integration and differentiation, Integration of vector-valued functions, Rectifiable curves. **{Chapter 6 [1]}** **[10 Lectures]**

Unit II: Sequences and Series of functions

Rearrangement of series, Pointwise and uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, Dirichlets test for uniform convergence, Equicontinuous families of functions, The Stone-Weierstrass theorem. **{Chapter 3[1] (3.52 to 3.55), Chapter 7[1] & Chapter 9[2] (9.11)}** **[20 Lectures]**

Unit III: Power Series

Uniqueness theorem for power series, Abel's limit theorem, Taubers first theorem. **{Chapter 8[1] (8.1 to 8.4) & Chapter 9[2] (9.23)}** **[10 Lectures]**

Unit IV: Functions of Several Variables

Linear transformations, Differentiation, The contraction principle, The inverse function theorem, The implicit function theorem, The rank theorem, Determinants, Derivatives of higher order, Differentiation of the integrals. **{Chapter 9[1] }** **[20 Lectures]**

Recommended Text Books:

[1] Walter Rudin: Principles of Mathematical Analysis, McGraw-Hill Book Company, 3rd Edition (1976).

[2] T. M. Apostol: Mathematical Analysis, Narosa Publishing House, 2nd Edition (1977).

Reference Books:

[1] S. C. Malik and Savita Arora: Mathematical Analysis, New Age International Publishers, 4th Edition (2010).

[2] Shanti Narayan: A Course of Mathematical Analysis, S. Chand & Company, New Delhi.

MT- 102: Topology

Unit I. Elements of Set theory:

Countable and uncountable sets, infinite sets and axiom of choice, cardinal numbers and its arithmetic, Schroeder-Bernstein theorem, Cantor's theorem, and the statements of continuum hypothesis, Zorn's lemma, well ordering theorem, Hausdorff Maximal principle. **[10 Lectures]**

Unit II. Metric Space:

$L^p(1 \leq p \leq \infty)$ spaces, Holders and Minkowski's inequality for L^pspaces, Neighborhood in metric spaces. **[5 Lectures]**

Unit III. Topological spaces:

Definition and examples of topological spaces, Elementary concepts, closed sets, exterior and boundary points, accumulation points and derived set, Open bases and open subbases, Subspaces and relative topology. First and second countable spaces, Lindelof's theorem Separable spaces, Countability and separatility. **[15 Lectures]**

Unit IV: Compactness:

Compact spaces, Basic properties of compactness, Compactness and finite intersection property, Sequentially and countably compact sets, product of spaces, Compactness in metric spaces, Equivalences of compactness, Countable compactness and sequential compactness in a metric space. {Sec. 21, 22, 24[3]} **[12 Lectures]**

Unit V. Separation:

$T_1, T_2, T_3, T_{3\frac{1}{2}}, T_4$ spaces, their characterization and basic properties. Urysohn's lemma, Tietze Extension theorem (statements). {Sec. 26, 27, 28[3], [4]} **[12 Lectures]**

Unit VI. Connectedness:

Connected spaces, The components of a space, Totally disconnected spaces, Locally connected spaces. **[6 Lectures]**

Textbooks:

1. Set Theory and related Topics, Schaum's outline series.
2. C. Goffman and G. Pedrick: First Course in Functional Analysis, Prentice Hall of India.
3. G. F. Simmons, Introduction to Topology & Modern Analysis.
4. W. J. Perwin, Foundation of General Topology.
5. J. R. Munkers, Topology, 2nd edition, Prentice Hall of India.

Reference Books:

1. M. J. Mansfield: Introduction to Topology.
2. K. D. Joshi: Introduction to General Topology.

MT-103: Discrete Mathematics

Unit I:Boolean algebra:

Definition and examples, subalgebra, direct product and homomorphism. Boolean functions, Boolean forms and free Boolean algebra, values of Boolean expression and Boolean functions. Representation and minimization of Boolean functions. Design examples with Boolean algebra. Applications of Boolean algebra to switching and circuits (Using AND, OR, & Not GATEs), the Karnaugh map. [1] Chapter 4: 4.2-4.5 [14 lectures]

Unit II: Graph Theory:

Definitions of graphs, paths, circuits, cycles, walk, subgraph, induced subgraphs, degree of vertex, connected graphs, components, Euler graphs, operations on graph, Hamiltonian path and circuits. Tree: properties of trees, distance and centers in tree, rooted and binary trees, spanning tree, fundamental circuits, cutsets, fundamental cutest, connectivity and separability, 1-isomorphism, 2-isomorphism, complete graph and bipartite graphs.
[2] Chapter 1, 2, 3, 4. [15 lectures]

Unit III: Graph Coloring:

Vertex coloring, critical graphs, Kirkman's Schoolgirls problem, chromatic polynomials. [3] Chapter-VII [8 lectures]

Unit-IV: Planarity:

Planar and nonplanar graphs, Euler formula and its consequences, K_5 and $K_{3,3}$ graphs, dual of plane graph, four color theorem and Heawood five color theorem, Kuratowski's theorem, Hamiltonian plane graphs.
[2] Chapter 5, [3] Chapter-VIII [8 lectures]

Unit-V:

Matrix representation of graphs and directed graphs, incident matrix, submatrices, circuit matrix, fundamental circuit matrix and rank of *B*, cutest matrix and fundamental cutest matrix, path matrix, adjacency matrix, diagraphs and binary relations. [2] Chapter 8, Chapter 9 (9.1-9.4) [15 lectures]

Recommended Text Books:

1. J. P. Tremblay and R. Manohar, "*Discrete Mathematical Structures with Applications to Computer Science*", Mc-Graw Hill Book co. 1997.
2. N. Deo, "*Graph Theory with applications to Engg, and Computer Science*", Prentice Hall of India.
3. R. Balkrishnan, K. Ranganathan, "*A Text Book of Graph Theory*", Sringer 2000.
4. W. T. Tutte, "*Graph Theory*", Cambridge University Press 2001.

MT-104: Abstract Algebra

Unit I: Groups:

Conjugate Classes, Sylow's theorems its applications, p-Sylow subgroups, Structure theorems for finite abelian groups, Normal and subnormal series, Jordan Holder theorem, Solvable groups. **{Chapter 1: Article 1.12, 1.13 and 1.14 [3]; Chapter 8: Article 1, 2 and 3 [2]}** **[25 Lectures]**

Unit II: Rings:

Euclidean rings, Polynomial rings, Polynomials over the rational fields, Einstein criterion, Polynomial rings over commutative rings, PID, UFD, UFD implies so is $R[x_1, x_2, \ldots, x_n]$. **{Chapter 3: Article 3.7 to 3.11 [1]}** **[20 Lectures]**

Unit III: Canonical form:

Similarity of linear transformations, Invariant subspaces, Reduction to triangular form, Nilpotent transformations, Index of nilpotency, Invariant of nilpotent transformations, Jordan blocks and Jordan forms. {**Chapter 6: Article 6.3 to 6.6 [1]}** **[15 Lectures]**

Recommended Text Books:

1. I. N. Herstein: **TOPICS IN ALGEBRA** (2nd Edition), Wiley Eastern Ltd, New Delhi, 1975.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul: **BASIC ABSTRACT ALGEBRA** (2nd Edition), Cambridge University press, Indian Edition, 1997.
3. N. S. Gopalkrishnan: **UNIVERSITY ALGEBRA**, Wiley Eastern Ltd, 1988.

Reference Books:

1. M. Artin: **ALGEBRA**, Prentice-Hall of India.
2. S. Lang: **ALGEBRA**, Addison Wesley.
3. Dummit and Foote: **ABSTRACT ALGEBRA,** Wiley - Eastern Ltd.

MT-105: LAB COURSE (C++ Programming and Numerical Analysis)

Unit I: COMPUTER PROGRAMMING IN C++:

1. Principles of Object-Oriented Programming.
2. Beginning with C++.
3. Tokens, Expressions and Control Structures.
4. Functions in C++.
5. Classes and Objects.
6. Constructors and Destructors.
7. Operator Overloading and Type Conversions.
8. Inheritance: Extending Classes.
9. Pointers, Virtual Functions and Polymorphism.
10. Managing Console I/O Operations.
11. Working with files **{Chapter 1 to 11 [1]}** **[35 Lectures]**

Unit II: Numerical Analysis:

Numerical solutions of algebraic equations, method of iteration and Newton-Raphson method, Rate of convergence, Solution of system of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

{Chapter 2 to 6 [2]} **[25 Lectures]**

Recommended Text Books:

1. E. Balaguruswamy: **OBJECT-ORIENTED PROGRAMMING WITH C++,** Tata McGraw Hill, New Delhi.
2. Jain, Iyengar, Jain: **NUMERICAL METHODS FOR SCIENTIFIC AND ENGINEERING COMPUTATION**; New Age International Ltd.

Reference Books:

1. Gottfried: **PROGRAMMING IN C++,** Schaum's Outline Series.
2. V. Rajaraman: **COMPUTER ORIENTED NUMERICAL METHODS**, 3rd Ed. Prentice-Hall.
3. S. S. Sastry: INTRODUCTORY **METHODS OF NUMERICAL ANALYSIS,** Prentice-Hall of India.

MT-201: - Complex Analysis

Unit I: Introduction, Complex integration, Cauchy-Goursat theorem, Cauchy integral formula, Higher order derivative, Morera's theorem. **{Chapter I [1] Art. 1 to Art. 6; Chapter 4 [2] Section 1 to Section 2}** **[12 Lectures]**

Unit II: Cauchy's estimates, Liouville's theorem, The fundamental theorem of algebra, Taylor's theorem, Maximum modulus principle, Schwartz lemma, Laurent's series, Isolated singularities. **{Chapter 4 [2] Section 3; Chapter 3 [3] Section 7 to Section 9}** **[12 Lectures]**

Unit III: Meromorphic functions, The argument principle, Rouche's theorem, Residues, Cauchy's residue theorem, Evaluation integrals, Branches of many valued functions with special reference to *arg z*, *log z,* and z^a. **{Chapter V [1] Art. 1 to Art. 3; Chapter 4 [2] Section 5; Chapter 2 [3] Section 3 to Section 4}** **[14 Lectures]**

Unit IV: Bilinear transformations, Their properties and classifications, Definitions and examples of conformal mappings. **{Chapter 5 [3] Section 1 to Section 2; Chapter 3 [2] Section 2.3 to Section 4.2}** **[12 Lectures]**

Unit V: Spaces of analytic functions, Hurwitz's theorem, Montel's theorem, Riemann mapping theorem, Riemann zeta function. **{Chapter VII [1] Art. 2, Art. 4 and Art. 8}** **[10 Lectures]**

Recommended Text Books:

1. Conway J. B.: Functions of One Complex Variable, Narosa Publishing House, Bombay.
2. Ahlfors L. V.: Complex Analysis, 3rd Edition, McGraw-Hill Book Company.
3. Levinson N. L. and Redheffer R. M.: Complex Variables, Holder-Day, Inc. (Holder-Day, Series in Mathematics)

MT-202 Measure and Integration Theory

Unit I. Measurable sets and functions:

Algebra of sets, Sigma Algebras, Borel sets, Lebesgue outer measure, Measurable sets and Lebesgue, Cantor set, A non-measurable set, measurable functions, Littlewoods Three principles, Egoroff's theorem on almost uniform convergence, Lusin's theorem. **[15 lectures]**

Unit II. The Lebesgue integral:

The Riemann integral and its drawbacks, The Lebesgue integral of a bounded function over a set of finite measure, Bounded convergence theorem, Lebesgue integral as an extension of Riemann integral over bounded interval, Lebesgue integral of non negative function, Fatou's lemma, Monotone convergence theorem, their equivalence on consequences, General Lebesgue integral, Dominated convergence theorem, Convergence in measure. **[15 Lectures]**

Unit III. Differentiation and Integration:

The four derivatives of Dini, Differentiation of monotone functions, Functions of bounded variation, Differentiation of an integral, Absolute continuity, convex functions. **[10 Lectures]**

Unit IV. Classical Banach Spaces:

The L^pspaces, Jensen, Holder, Minkowski and Schwarz inequalities. Types of convergence: Uniform, almost uniform, point wise, almost everywhere, Convergence in mean, Convergence in measure. Completeness of L^p, $1 \leq p \leq \infty$, Bounded linear functional on L^pspaces. **[10 Lectures]**

Unit V: Abstract Measure Spaces:

Measures and outer measures, Extension of measure, uniqueness of the extension, Completion of measure, Measure spaces, Integration with respect to a measure.

[10 Lecture]

Recommended Text Books:

1. H. L. Roydon, Real Analysis, 3rd edition Prentice Hall of India. [Chapter 1 § 4, Chapter 2 § 7, chapters 3, 4 and 5].
2. G. de Barra, Measure theory and integration New age publication/ Wiley eastern Ltd. [Chapter 5].

Reference Books:

1. M. E. Munroe: Introduction to measure and integration.
2. R. G. Bartle: The Elements of Integration.
3. P. K. Jain and V. P. Gupta: Lebesgue Measure and Integration, Wiley eastern ltd., 3rd edition.

MT-203: - Ordinary Differential Equations

Unit I:System of Linear Differential Equations:

Systems of first order equations, Model for arms competition between two nations, Existence and uniqueness theorem, Fundamental matrix, Non-homogeneous linear systems, Linear systems with constant coefficients, Linear systems with periodic coefficients. [12 Lectures]

Unit II: Existence and Uniqueness of Solutions:

Successive approximations, Picard's theorem, Continuation and dependence on initial conditions, Existence of solutions in the large, Existence and uniqueness of solutions of systems, Fixed point method. [12 Lectures]

Unit III: Analysis and Method of Nonlinear Differential Equations:

Existence theorem, Extremal solutions, Upper and lower solutions, Monotone iterative method and method of quasilinearization, Bihari's inequality, Variation of parameters. [10 Lectures]

Unit IV: Boundary Value Problems:

Sturm-Liouville problem, Green's function, Application of boundary value problems (BVP), Picard's theorem. [08 Lectures]

Unit V: Oscillations of Second Order Equations:

Fundamental results, Sturm's comparison theorem, Elementary linear oscillations, Comparison theorem of Hille-Winter, Oscillations of $x''+a(t)x=0.$ [06 Lectures]

Unit VI: Stability of Linear and Nonlinear Systems:

Elementary critical points, System of equations with constant coefficients, Linear equation with constant coefficients, Lyapunov stability, Stability of quasilinear systems, Second order linear differential equations. [12 Lectures]

Recommended Text Books:

1. S. G. Deo, V. Lakshmikantham and V. Raghavendra: Text Book of Ordinary Differential Equations, Tata Mc-Graw Hill Publishing Company Limited, New Delhi (1997).

Reference Books:

1. Earl A. Coddington and Norman Levinson: Theory of Ordinary Differential Equations, McGraw Hill, New York (1972).
2. G. F. Simmons: Differential Equations with Applications and Historical Notes, 2nd Ed., McGraw- Hill, 1991.
3. David A. Sanchez: Ordinary Differential Equations and Stability Theory: An Introduction, Dover Publications, Inc., New York (1968).

MT-204: Finite Fields and Algebraic Coding Theory

Unit I: Prerequisites:

Rings, Fields and Polynomials ([1] Chapter 1, Art. 2, 3), Field extension ([1] Chapter 1, Art. 4), Algebraic extension splitting fields. **[13 Lectures]**

Unit II: Structure of Finite Fields

Characterization of finite fields, Roots of irreducible polynomials, Traces, Norms and Bases, Roots of unity and cyclotomic polynomials, Representation of elements of finite fields. **([1] Chapter 2, Except Art. 6)** **[12 Lectures]**

Unit III: Polynomials over Finite Fields

Order of polynomials and primitive polynomials, Irreducible polynomials, Construction of irreducible polynomials, Factorization over finite fields. **([1] Chapter 3)** **[15 Lectures]**

Unit IV: Algebraic Coding Theory

Linear codes, Cyclic codes, Goppa codes. **([1] Chapter 8)** **[20 Lectures]**

Recommended Text Books:

1. Rudolf Lidl and Harald Niederreiter: Introduction to Finite Fields and their Applications, Cambridge University Press, Cambridge (1986).

Reference Books:

1. Gopalkrishnan, University Algebra.
2. Herstein I. N., Topics in Algebra.
3. Birkhoff G. and Bartee T. C., Modern Applied Algebra, McGraw Hill, New York (1970).
4. Berlekamp E. R., Algebraic Coding Theory, McGraw Hill, New York (1968).

MT-205: Lab Course (MATLAB Programming)

Theory: 4 lectures per week (Total 60 hrs); Practical: 6 hours per week

Unit I: MATLAB ENVIROMENT:

1.1 MATLAB windows

1.2 Variables

1.3 Working with Matrices

1.4 Saving Variables

1.5 Script M-files

Unit II: PREDEFINED MATLAB FUNCTIONS:

2.1 Elementary Math functions

2. 2 Trigonometric functions

2.3 Data analysis functions

2.4 Random numbers

2.5 Defining matrices

2.6 Using the colon operator

2.7 Special values and functions

Unit III: PLOTTING:

3.1 Introduction

3.2 Two dimensional plots

3.3 Basic plotting

3.4 Line, color, and mark style

3.5 Axes scaling

3.6 Others types of two dimensional plot

3.7 Three dimensional plotting

3.8 Three dimensional line plot

3.9 Surface plots

Unit IV: PROGRAMMING IN MATLAB:

4.1 Introduction

4.2 Problems with two variables

4.3 Input/output

4.4 User defined Input

4.5 Output options

4.6 Functions

4.7 Statement level control structures

4.8 Relational and logical operators

4.9 Loops

Unit V: MATRIX COMPUTATIONS:

5.1 Matrix operations and functions

5.2 Solutions to system of linear equations

5.3 Special Matrices

Unit VI: SYMBOLIC MATHEMATICS:

6.1 Symbolic Algebra

6.2 Equation Solving

6.3 Differentiation and Integration

Unit VII: NUMERICAL TECHNIQUES:

7.1 Interpolation

7.2 Numerical Integration

7.3 Numerical Differentiation

Recommended Text Books:

1. Delores M. Etter, David C. Kuncicky and Holly Moore: *"Introduction to MATLAB"*, Dorling Kindersley (India) Pvt. Ltd. New Delhi, (2009).

Reference Books:

1. Brian R. Hunt, Ronald L. Lipsman and Jonathan M. Rosenberg: *"A Guide to MATLAB"*, Cambridge University Press, (2008).
2. Y. Kirani Singh and B. B. Chaudhari: *"MATLAB Programming"*, PHI Learning Private Ltd., New Delhi, (2010).

MT-301: Functional Analysis

Unit I:Fundamental of Normed spaces:

Normed spaces, Continuity of linear maps, Hahn - Banach theorems, Banach spaces. {Chap II, 5 to 8}. [12 Lectures]

Unit II: Bounded Linear Maps on Banach Spaces:

Uniform bounded principle, Closed graph theorem, Open mapping theorem, Bounded inverse theorem. {Chap III, 9 to 11}. [12 Lectures]

Unit III: Spaces of bounded Linear functional:

Autonomous Weak and weak* convergences, Reflexivity. {Chap IV, 15 to 16}. [12 Lectures]

Unit IV: Hilbert spaces:

Inner product spaces, orthonormals sets, Projection and Riesz representation theorem. {Chap VI, 21, 22, 24}. [12 Lectures]

Unit V: Bounded Operators on Hilbert Spaces:

Bounded operators, Adjoint, Normal, Unitary and Self Adjoint Operators. [12 Lectures]

Recommended Text Books:

[1] B. V. Limaye, *Functional Analysis*, New Age International Limited, New Delhi (1996).

Reference Books:

[1] Erwin Kreyszig, *Introductory Functional Analysis with Applications*, John Wiley (2007).

[2] G. F. Simmon, *Introduction to General Topology and Modern Analysis*, Mc-Graw Hill (2004).

MT-302: Partial Differential Equations

Unit I: Partial Differential Equations of First Order:

Partial Differential Equations of First Order in two variables, Cauchy problem, Semi linear and quasilinear equations in two independent variables, Characteristic Cauchy problem, Monge strip and Charpit equations, Complete integral. {[1] Chapter 1: 1.1, 2.1, 2.2, 2.3, 2.4, 3.1, 3.2, 3.3, 4.1, 4.2} [12 Lectures]

Unit II: Partial Differential Equations of Second Order:

Classification of second order partial differential equations, Linear equation in two independent variables, More than two independents variables, Reduction to normal forms, Cauchy problem. {[1] Chapter 2: 1.1-1.3, [4] Chapter 0: 0.1-0.2} [12 Lectures]

Unit III: Laplace Equation:

Mean value property, Weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, Existence of solution using Perron's method (without proof), Solutions by method of separation of variables.

{[2] Chapter 4; [1] Chapter 2, 2.1-2.4} [12 Lectures]

Unit IV: Heat Equations:

Fundamental solution, Mean value formula, Strong maximum principle, Uniqueness, Regularity, solutions by method of separation of variables. {[3] Chapter 2: 2.3.1-2.3.3} [12 lectures]

Unit V: Wave Equations:

One dimensional wave equation, D'Alembert's method, Method of spherical means, Duhamel's principle and solutions by method of separation of variables. {[4] Chapter 3: 3.3; [3] Chapter 2: 2.4.1-2.4.3} [12 Lectures]

Recommended Text Books:

[1] Phoolan Prasad, Renuka Ravindran, *Partial Differential Equations,* Wiley Eastern Limited, New Delhi (1987).

[2] Fritz John, *Partial Differential Equations,* Springer International Edition, Second Indian Reprint (2009).

[3] Lawrence C Evans, *Partial Differential Equations,* American Mathematical Society, Providence, Rhode Island (Indian edition 2009).

[4] Mark A. Pinsky, *Partial Differential Equations and Boundary Value Problem with Applications,* McGraw-Hill, Ins. (1991).

[5] Ian Sneddon, *Elements of Partial Differential equations,* McGraw-Hill.

MT-303 (A): Classical Mechanics

Unit I: Variational Problems With Fixed and Boundaries:

The Concept of variation and its properties, Euler's equation, Variational problems for functional of the form, Functionals dependent on Higher order derivatives, Functional dependent on functions on several independent variables, Variational problems in parametric form, Functional of the form $I[y(x)] = \int_{x_1}^{x_2} F(x, y, y')dx$, Variational problem with a movable boundary for a functional dependent on two functions. ([2], Chap 1: 1.1 to 1.6, Chap 2: 2.1, 2.2). [12 Lectures]

Unit II: Survey of the Elementary Principle:

Mechanics of a particle, Mechanics of a system of particle, Constraints, D'Alembert's principle and Lagrange's equation, Velocity-dependent potential and the dissipation function, Simple applications of the Lagrangian formulation. ([1], Chap 1: 1 to 6). [8 Lectures]

Unit III: Variational Principles and Lagrange's Equation:

Hamilton's principle, Derivation of Lagrange's equations from Hamilton's principle, Extension of Hamilton's principle to nonholonomic system, Advantages of a variational principle formulation, Conservation theorems and symmetry properties. ([1], Chap 2: 1 to 6). [10 Lectures]

Unit IV: The Hamilton Equation of Motion:

Legendre transformations and the Hamilton equations of motion, Cyclic coordinates and conservation theorems, Routh's procedure and oscillations about steady motion, Derivation of Hamilton's equation from a variational principle, The principle of least action. ([1], Chap 8: 1 to 3, 5,6). [10 Lectures]

Unit V: Canonical Transformations:

The equations of canonical transformation, Examples of canonical transformations, Poisson brackets and other canonical invariants, Equations of motion, infinitesimal canonical transformations and conservations theorems in the poisons bracket formulation. ([1], Chap 9: 1, 2, 4, 5) [8 Lectures]

Unit VI: Hamilton-Jacobi Theory:

Hamilton-Jacobi equation for Hamilton's principle function, The Harmonic oscillator problem as an example of the Hamilton-Jacobi method, The Hamilton-Jacobi equation for characteristic function, Separation of variables in the Hamilton-Jacobi equation ([1], Chap 10: 1 to 4). [12 Lectures]

Recommended Text Books:

[1] Herbert Goldstein, *Classical Mechanics*, Narosa Publishing House, (1993) (Reprint).

[2] A. S. Gupta, *Calculus of Variation with Application*, Prentice-Hall of India Private Limited, New Delhi, (2005).

Reference Book:

[1] G. Aruldhas, *Classical Mechanics*, Phi learning Pvt Ltd (First Edition), (2009).

[2] Madhumangal Pal, *A Course on Classical Mechanics*, Narosa Book Distributors Private Ltd, (2008).

[3] Gupta, Kumar, Sharma, *Classical Mechanics*, Pragati Prakashan, (2010).

MT-303(B): Commutative Algebra

Unit I:Modules:

Free modules, Projective modules, Tensor products, Flat modules. {[1] Chapter-I, 1.1-1.4}
[12 Lectures]

Unit II: Localization:

Ideals, Local rings and localization. {[1] Chapter-II, 2.1-2.3} [12 Lectures]

Unit III: Noetherian Rings:

Noetherian modules, Primary decomposition, Artinian modules. {[1] Chapter-III, 3.1-3.3}
[12 Lectures]

Unit IV: Integral Extensions:

Integral elements, Integral extensions, integrally closed domains. {[1] Chapter-III, 3.1-3.3}
[12 Lectures]

Unit V: Dedekind Domains:

Valuation rings, Discrete valuation rings, Dedekind domains. {[1] Chapter-III, 3.1-3.3}
[12 Lectures]

Recommended Text Books:

[1] N. S. Gopalkrishnan, *Commutative Algebra*, Oxonian Press, New Delhi (1984).

Reference Books:

[1] M. F. Atiyah and I. G. Macdonald, *Introduction to Commutative Algebra*, Addison-Wesley, Reading, MA (1969).

[2] H. Matsumura, *Commutative Algebra*, Benjamin, New York (1970).

MT-303(C): Special Functions

Unit I: The Gamma & Beta Functions:

The Gamma and Beta integrals, Functions and their properties, The Euler Reflection formula, Riemann Zeta functions, Gauss's multiplication formula for $\Gamma(mx)$, Integral representation for Log $\Gamma(mx)$, The Bohr-Mollerup theorem.

{[1] Chapter 1; 1.1, 1.2, 1.3, 1.5, 1.6, 1.9} [15 lectures]

Unit II: Legendre Polynomials:

Solution of Legendre differential equation and Legendre polynomials, Rodrigue's formula, Generating function, Recurrence relations, Orthogonal and orthonormal functions, Orthogonal property of Legendre's polynomials, Fourier Legendre's series.

{[2] Chapter 7; 7.1, 7.2, [3] Chapter 4; 4.2} [15 lectures]

Unit III: Bessel's Functions:

Solution of Bessel's differential equation and Bessel's functions, Bessel's function of first kind and second kind, Orthogonality of Bessel's functions, Fourier Bessel's series.

{[2] Chapter 7; 7.4, 7.5, [3] Chapter 3; 3.2} [15 lectures]

Unit IV: The Hypergeometric Functions:

The Hypergeometric series, Euler's Integral Representation, the Hypergeometric equation, the Barnes Integral for the Hypergeometric function.

{[1] Chapter 2; 2.1, 2.2, 2.3, 2.4} [15 lectures]

Recommended Text Books:

[1] George E. Andrews, Richard Askey, Ranjana Roy, *Special Functions,* Cambridge University Press, (2010).

[2] R. K. Jain and S. R. K. Iyengar *Advanced Engineering Mathematics,* Narosa Publishing House, New Delhi, (2008).

[3] Mark A. Pinsky, *Partial Differential Equations and Boundary Value Problem with Applications,* McGraw-Hill, Ins. (1991).

Reference Books:

[1] Earl D. Rainville, *Special Functions,* Chelsea Publishing Company, New York, (1960).

[2] H. M. Srivastava, *A Treatise On Generating Functions,* John Wiley & Sons, New York.

MT-304(A): Operation Research

Unit I: Convex Set and Functions:

Convex set, Supporting and separating hyperplanes, Convex polyhedron and polytope, Convex functions, Generalized convexity. Linear programming model, Graphical solution of some linear programs, Standard Linear Program and basic Solution, Simplex Algorithm and Simplex method, Charnes M-Technique, Applications, Dual Linear program, Simplex multipliers, Duality Theorems and Dual Simplex method. {[1], Chap 2: 2.1 to 2.5, Chap 3: 3.1 to 3.6, Chap 4: 4.1 to 4.3, 4.5} [16 Lectures]

Unit II: Transportation Programming:

Balanced transportation problem, Unbalanced transportation problem, Transportation paradox, Assignment problem, Hungarian method of assignment.

{[1], Chap 5: 5.1 to 5.5} [8 Lectures]

Unit III: Methods for Special Linear Programs and Integer Programming:

Gomory's algorithm for pure integer linear programs, Branch and bound methods. {Chap 6, 6.4, 6.6} [8 Lectures]

Unit IV: Quadratic Programming and Complementarily Problems:

Quadratic program, Wolfe's algorithm, Beale's algorithm. {Chap 10, 10.1 to 10.3}.

[8 Lectures]

Unit V: Nonlinear Programming Methods:

Frank Wolfe method, Reduced Gradient method, Kelley's cutting plane method, method of approximate programming, Gradient projection method, Generalized Lagrange multiplier technique, Separable programming, Linear fractional programming, Nonlinear fractional programming. [12 Lectures]

Unit VI: Game Theory:

Game theory problem, Two person zero sum game, Finite matrix game, Graphical method for $2 \times n$ and $m \times 2$ matrix game, Some theorems, Dominance principle, {Chap 16, 16.1 to 16.6}

[8 Lectures]

Recommended Text Books:

[1] N. S. Combo, *Mathematical programming Techniques*, Affiliated East-West Press PVT, New Delhi, (1991).

Reference books:

[1] H. A. Taha, *Operations Research: An Introduction*, Prentice Hall of India, (1997).

[2] Kanti Swarup, P. K. Gupta and Man Mohan, *Operations Research,* Sultan Chand & Sons, new Delhi, (1991).

MT-304(B): Stability Theory

Unit I: Linear Systems:

Coupled and uncoupled systems, fundamental theorem, Linear System in $\mathbb{R}2$, phase space, Phase portrait, Critical points classification, Complex eigenvalues.

{[1] Chapter-1: 1.1, 1.2, 1.4-1.9} [15 Lectures]

Unit II: Nonlinear Systems:

Critical points of nonlinear systems, maximum interval of existence, Flow defined by differential equations, Linearization, Stable manifold theorem, Center manifold theorem, Stability and Liapunov functions.

{[1] Chapter-2: 2.4-2.9} [16 Lectures]

Unit III: Stability and Perturbation Theory:

Asymptotic stability & instability solutions, Stability of periodic solution of autonomous equations, Introduction to perturbation theory, Näive expansion, Poincare theorem. {[2] Chapter-7: 7.1-7.3, Chapter-9: 9.1-9.3} [15 Lectures]

Unit IV: Bifurcations:

Saddle node bifurcation, Andronov-Hopf bifurcation, Saddle connections, Semi stable limit cycle, Bifurcation in one parameter families. {[3] Chapter-9: 9.1-9.4} [14 Lectures]

Recommended Text Books:

[1] Lawrence Perko, *Differential Equations and Dynamical Systems,* Springer-Verlag (1998).

[2] Ferdinand Verhulst, *Nonlinear Differential Equations and Dynamical Systems,* Springer-Verlag (2000).

[3] J. H. Hubbard and B. H. West, *Differential Equations: A Dynamical system Approach (Higher Dimensional Systems),* Springer-Verlag (1995).

Reference Books:

[1] Hahn, *Stability of Motion,* Springer-Verlag.

[2] T. A. Burton, *Periodic Solutions of Ordinary and Fundamental Differential Equations,* Academic Press (1985).

[3] David R. Merkin, *Introduction to the Theory of Stability,* Springer-Verlag.

MT-304(C) Financial Mathematics

Unit I: The Measurement of Interest:

Introduction, The accumulation and amount functions, The effective rate of interest, Simple interest, Compound interest, Present value, The effective rate of discount, Nominal rates of interest and discount, Forces of interest and discount, Varying interest, Summary of results. [9 Lectures]

Unit II: Solution of Problems in Interest:

Introduction, The basic problem, Equation of value, Unknown time, Unknown rate of interest, Determining time periods, Practical examples. [7 Lectures]

Unit III: Basic Annuities:

Introduction, Annuity-immediate, Annuity-due, Annuity values on any date, Perpetuities, Unknown time, Unknown rate of interest, Varying interest, Annuities not involving compound interest. [9 Lectures]

Unit IV: More General Annuities:

Introduction, Differing payment and interest conversion periods, Annuities payable less frequently than interest convertible, Annuities payable more frequently than interest convertible, Continuous annuities, Payments varying in arithmetic progression, Payments varying in geometric progression, More general varying annuities, Continuous varying annuities, Summary of results. [9 Lectures]

Unit V: Amortization Schedules and Sinking Funds:

Introduction, Finding the outstanding loan balance, Amortization schedules, Sinking funds, Differing payment periods and interest conversion periods, Varying series of payments, Amortization with continuous payments, Step-rate amounts of principal. [9 Lectures]

Unit VI: Bonds and Other Securities:

Introduction, Types of securities, Price of a bond, Premium and discount, Valuation between coupon payment dates, Determination of yields rates, Callable and putable bonds, Serial bonds, some generalizations, other securities, Valuation of securities. [9 Lectures]

Unit VII: Yield Rates:

Introduction, Discounted cash flow analysis, Uniqueness of the yield rate, Reinvestment rates, Interest measurement of a fund, Time-weighted rates of interest, Portfolio methods and investment year methods, Short sales, Capital budgeting-basic technique and other technique. [8 Lectures]

Recommended Text Books:

[1] Stephen G. Kellison, *The Theory of Interest*, 3rd Edition. McGraw Hill International Edition (2009).

[2] R. J. Elliott and P. E. Kopp, *Mathematics of Financial Markets*, Springer (1999).

MT-305: Lab Course-III

Practicals based on courses: MT-302, MT-303, MT-304 using MATLAB

List of Practicals:

1. **Classifications of second order partial differential equations in two variables with constant coefficients.**
2. **Classifications of second order partial differential equations in more than two variables with constant coefficients.**
3. **Solutions of boundary value problems of Laplace's equations in two variables.**
4. **Solutions of boundary value problems of Heat equations in one variable.**
5. **Solutions of boundary value problems of wave equations in one variable.**
6. **Solutions of variational problem with movable boundary.**
7. **Solution of Lagrange's equation.**
8. **Solution of Hamiltonian equation.**
9. **Evaluation of beta and gamma functions.**
10. **Solutions of problems based on operational research**

Unit I: Modelling Through Ordinary Differential Equations:

Review of integration and differentiation, Numerical integration, Numerical differentiation, Analytic solutions to differential equations, ODE Solvers in the control system toolbox, Advanced solver syntax, Numerical Methods for differential equations: Linear growth and decay models, nonlinear growth and decay models, Population dynamics, Circular motion and motion of satellites and Economics, Extension to higher-order equations and Simulink. [20 Lectures]

Unit II: Modelling Through Partial Differential Equations:

Introduction, Getting started, Using the Graphical User Interface (GUI), Using Command-Line functions, Examples of Elliptic Problems (Poisson's equation on unit disk, A scattering problem, A minimal surface problem), Examples of Parabolic Problems (The heat equation, Heat distribution in radioactive rod) and Examples of Hyperbolic Problems(The wave equation) [25 Lectures]

Unit III: Modelling Through Linear Programming Problems:

MATLAB functions, Auxiliary MATLAB functions, Basic feasible solutions, Extreme points and extreme directions of the constraint set, Solving the LLP by geometrically, The two phase method and The dual simplex algorithm. [15 Lectures]

Recommended Text Books:

[1] William J. Palm III, *Introduction to MATLAB for Engineers,* McGraw-Hill, International Edition (2001).

[2] J. N. Kapur, *Mathematical Modelling,* Wiley Eastern Limited, New Delhi ().

[3] *Partial Differential Equation Toolbox User's Guide,* The MathWorks, Inc. (1984 - 1997).

[4] *Optimization Toolbox User's Guide,* The MathWorks, Inc. (1990 - 2001).

MT-401: - Analytic Number Theory

Unit I:The fundamental theorem of arithmetic:

Divisibility, Greatest common divisor, Prime numbers, The fundamental theorem of arithmetic, The Euclidean algorithm, The gcd of more than two elements. [8 Lectures]

Unit II: Arithmetic functions and Dirichlet multiplication:

The Mobious function $\mu(n)$, The Euler totient function $\phi(n)$, A relation connecting μ, ϕ, A product $\phi(n)$, Dirichlet product of arithmetic functions, Dirichlet inversion and Mobious inversion formula, The Mangoldt function $\Lambda(n)$, Multiplicative functions and Dirichlet multiplication, The inverse of completely multiplicative function, Liouville function, The divisor function, Generalized convolution. [15 Lectures]

Unit III: Congruences:

Definition and basic properties of congruences, Residue classes and complete residue system, Linear congruences, Reduced residue system and Euler-Fermat theorem, Polynomial congruences modulo p, Lagrange theorem, Application of Lagrange's theorem: Simultaneous linear equations, The Chinese remainder theorem and its applications, Polynomial congruences and prime power modulli. [15 Lectures]

Unit IV: Quadratic residues and Quadratic reciprocity law:

Quadratic residue, Legendre's symbol and its properties, Evaluation of $(-1/p)$ and $(2/p)$, Gauss lemma, The quadratic reciprocity law, Application of reciprocity law, The Jacobi symbol. [10 Lectures]

Unit V: Primitive roots:

The exponent of a number modulo m, Primitive roots, Primitive roots and reduced residue system, The non existence of primitive roots and mod 2^{α} for $\alpha \geq 3$, The existence of primitive roots mod p, The non existence of primitive roots mod m, The primitive roots and quadratic residues, The index calculus. [12 Lectures]

Recommended Text Books:

[1] T. M. Apostol, *Introduction to Analytic Number Theory*, Narosa Publishing House (1980).

Reference Books:

[1] Ivan Niven and H. S. Zuckerman, *An Introduction to the Theory of Numbers*, Wiley East (2001).

[2] D.M. Burton, *Elementary Number Theory*, Tata McGraw Hill Education Private Limited (2009).

MT-402: Transform Theory

Unit I: Laplace Transform:

Properties of Laplace Transform, Laplace Transform of the derivatives of function, Inverse Laplace transform, Properties of inverse Laplace transform, Inverse Laplace transform of derivatives, Convolution theorem, Heaviside's expansion theorem. Application of Laplace Transform, Solution of ODEs and PDEs. [14 lecture]

Unit II: Fourier Integrals & Fourier Transforms:

Fourier integral theorem, Fourier transform Pairs, Properties of Fourier transform, Fourier cosine transform, Inverse Fourier Transform, Inverse Fourier sine Transform, Inverse Fourier cosine Transform, Properties of Fourier Transforms, Modulation theorem, Convolution theorem, Fourier Transform of the derivatives of functions, Parseval's identity, Application of Fourier Transforms to the solution of initial & boundary value problems. [14 lectures]

Unit III: Mellin Transform:

Evaluation of Mellin transforms, Complex variable method and Applications.

[10 lectures]

Unit IV: The Henkel Transforms:

The Henkel transforms and its applications [10 lectures]

Unit V: Finite Transforms:

Finite Fourier transform, Z- transform, Solutions of difference equations using Z- Transform. [12 lectures]

Recommended Text Books:

[1] Larry Andrews, Bhimsen Shivamoggi, *Integral Transforms for Engineers,* Prentice Hall of India, New Delhi, 2005.

Reference Books:

[1] I. N. Sneddon, *Fourier Transforms,* McGraw Hill

[2] Vashishtha and Gupta, *Integral Transforns*

[3] Goyal and Gupta, *Integral Transforns.*

[4] Bracemell, *Fourier Transforms and Its Applications.*

MT-403(A): Fluid Dynamics

Unit I: Vector Analysis:

Differentiation of vector and scalar functions, Gradient of scalar function, Divergence, Curl, Directional derivatives, Unit normal to surface, Angle between surfaces, Physical interpretation of curl, Divergence and gradient, Orthogonal curvilinear coordinates, Conservative vector fields. [10 lectures]

Unit II: Kinematics of Fluids in Motion:

Real and ideal fluids, Velocity of fluid, Streamlines and path lines, Velocity potential, Local and particle rate of change, Equation of continuity, Acceleration of fluid Conditions at rigid boundary. {[1] Chapter 2} [10 lectures]

Unit III: Equations of Motion of Fluid:

Pressure at appoint in fluid, Euler's equation of motion, Bernoulli's equation, Potential theorems, Flow involving axial symmetry, Special two dimensional flows. **{**[1] Chapter 3} **[**12 lectures]

Unit IV: Three Dimensional Flows:

Introduction, Sources, Sinks and doublets, Images in rigid infinite plane, Images in solid sphere, Tokes's Stream function. {[1] Chapter 4} [12 lectures]

Unit-V: **Two Dimensional Flows:**

Meaning of two dimensional flows, Use of cylindrical polar coordinates, Stream function, Complex velocity potentials for standard two dimensional flows.

{[1] Chapter 5: 5.1-5.6} [8 lectures]

Unit VI: Viscous Flows:

Stress components in real fluid, Relation between Cartesian Components of stress, Translational motion of fluid element, Relation between stress and rate of strain, The Navier-Stokes equations of motion of a viscous fluid.

{[1] Chapter 8: 8.1, 8.2, 8.3, 8.7, 8.9} [8 lectures]

Recommended Text Books:

[1] F. Chorlton, *Text Book of Fluid Dynamics,* CBS Publishers and Distributors, (1985).

Reference Book:

[1] A. J. Chorin & A. Marsden: *A Mathematical Introduction to Fluid Dynamics*, Springer Verlag, (1993).

[2] L. D. Landu & E. M. Lipschitz, *Fluid Mechanics,* Pergamon Press, (1985).

[3] L. M. Milne Thomson, *Theoretical Hydrodynamics,* MacMilan & Co., (1938).

MT-403(B): Linear Integral Equations

Unit I:Fredholm and Volterra integral equations:

Regularity conditions, Special kinds of kernels, Eigen values and eigen functions, Convolution integral, Reduction to a system of algebraic equations, Fredholm alternative, An approximate method, Examples, Iterative scheme, Volterra integral equation, Some results about the Resolvent kernel, Examples. [15 Lectures]

Unit II: Classical Fredholm Theory:

The method of solution of Fredholm, Fredholm's first theory, Examples. [8 Lectures]

Unit III: Applications to ordinary differential equations:

Initial value problems, Boundary value problems, Dirac delta function, Green's function approach, Green's function for N^{th} – order ordinary differential equation, Modified Green's function, Examples. [12 Lectures]

Unit IV: Symmetric kernels:

Introduction, Fundamental properties of eigenvalues and eigenfunctions for symmetric kernels, Expansion in eigenfunctions and bilinear form, Hilbert-Schmidt theorem and some immediate consequences, Solution of a symmetric integral equation, Examples.

[15 Lectures]

Unit V: Singular integral equations and Integral Transform Methods:

Abel's equations, Inversion formula for singular integral equations, Laplace transform, Applications to Volterra integral and integrodifferential equations with convolution type kernels, Abel's integral equation, Fourier transform, Solution by Fourier transform method.

[10 Lectures]

Recommended Text Books:

[1] R. P. Kanwal, *Linear Integral Equations*, Theory and Techniques, Academic Press (1971).

[2] S. G. Mikhlin, *Integral Equations*, Pergamon Press, Oxford (1957).

[3] A. M. Wazwaz, *A first Course in Integral Equations*, World Scientific, (1997).

Reference Books:

[1] J. A. Cochran, *The Analysis of Linear Integral Equations*, Mc-Graw Hill, (1972).

[2] L. G. Chambers, *Integral Equations: A Short Course*, International Text Book Co., (1976).

[3] M. A. Krasnow, Kislov and G. Hakaronke, *Problems and Exercises in Integral Equations*, Mir Publications (1971).

MT-403(C): Difference Equations

Unit I:Difference Calculus:

Introduction, The Difference Operator, Summation, Generating Functions and Approximate Summation. [15 Lectures]

Unit II: Linear Difference Equations:

First Order Equations, General Results for Linear Equations, Solving Linear Equations, Applications, Equations with Variable Coefficients, Nonlinear Equations that can Be Linearized, The z-Transform. [15 Lectures]

Unit III: Stability Theory:

Initial Value Problems for Linear Systems, Stability of Linear Systems, Phase Plane Analysis for Linear Systems, Fundamental Matrices and Floquet Theory, Stability of Nonlinear Systems, Chaotic Behavior. [15 Lectures]

Unit IV: Asymptotic Methods:

Introduction, Asymptotic Analysis of Sums, Linear Equations, Nonlinear Equations. [15 Lectures]

Recommended Text Books:

[1] Walter Kelley and Allan Peterson, *Difference Equations, An Introduction with Applications*, Academic Press (1991).

[2] Calvin Ahlbrant and Allan Peterson, *Discrete Hamiltonian Systems, Difference Equations*, Continued Fractions and Riccati Equations, Kluwer (1996).

Reference Books:

[1] Saber Elaydi, *An Introduction to Difference Equations*, Springer (1999).

MT-404(A): Fuzzy Sets and Applications

Unit I: From Classical (Crisp) Sets To Fuzzy Sets:

Introduction, Crisp sets: an over view, Fuzzy sets: basic types, basic concepts, Characteristics and significance of the paradigm Shift. {[1], Chap:1} [10 lectures]

Unit II: Fuzzy Sets Verses Crisp Sets:

Additional Properties of $\propto$-cuts, Representation of fuzzy sets, Extension principle of fuzzy sets. {[1], Chap: 2} [10 Lectures]

Unit III: Operations on Fuzzy Sets:

Types of operations, Fuzzy complements, Fuzzy intersections: t-norms, Fuzzy unions: t-norms, Combination of operations, Aggregation operation. {[1], Chap: 3}. [10 Lectures]

Unit IV: Fuzzy Arithmetic and Relations:

Fuzzy numbers, Linguistics Variables, Arithmetic Operations on intervals, Arithmetic Operations on fuzzy numbers, lattice of fuzzy numbers, Fuzzy equations, Crisp verses fuzzy relations, projections and cylindric extension, Binary relations, Binary relations on a single set, Fuzzy equivalence relations, Fuzzy compatibility relations, Fuzzy ordering relations, Fuzzy morphisms. {[1], Chap: 4 & 5} [15 Lectures]

Unit V: Possibility Theory:

Fuzzy measure, Evidence Theory, Possibility Theory, Fuzzy sets and possibility Theory, Possibility theory verses probability theory, Applications. {[1], Chap: 7} [15 Lectures]

Recommended Text Books:

[1] G. J. Klir and B. Yuan, *Fuzzy Sets and Fuzzy Logic*, Prentice-Hall India, New Delhi, (1995).

Reference Books:

[1] H. J. Zimmermann, *Fuzzy Set Theory and Its Applications*, Springer, (2001).

[2] Didier Dubois and Henri Prade, *Fuzzy Sets and Systems: Theory and Applications*, Academic Press, (1980).

MT-404(B): Non-Commutative Rings

Unit I: Wedderburn-Artin Theory:

Basic terminology and examples, Semisimplicity, Structure of semi simple rings.

{[1] Chapter-1, Article: 1-3} [20 lectures]

Unit II: Jacobson Radical Theory:

The Jacobson radical. {[1] Chapter-2, Article: 4} [15 Lectures]

Unit III: Prime and Primitive Rings:

The prime radical, Prime and semiprime rings, Structure of primitive rings, The Density theorem, Subdirect sums and commutativity theorems.

{[1] Chapter-4, Article 10-12} [25 Lectures]

Recommended Text Books:

[1] T. Y. Lam, *Non - Commutative Rings*, Springer Verlag, (1991).

Reference Books:

[1] I. N. Herstein, *Non - Commutative Rings*, Carus Monographs of AMS, (1968).

MT-404(C) Actuarial Mathematics

Unit I: Random Variable and Probability Distributions:

Discrete random variables, Some discrete probability distributions, Discrete Uniform, Binomial, Negative Binomial, Geometric and Poisson distribution, Some continuous probability distributions: Continuous Uniform, Normal, Exponential, and Gamma distribution. [11 Lectures]

Unit II: Introduction to Life Insurance. [2 Lectures]

Unit III: Survival Distributions and Life Tables:

Probability for the Age-at-Death, The survival function, time- until-death for a person aged *x, C*urtate-future-lifetime, Force of mortality, Life tables, Relation of life table functions to the survival function, Life table examples, The deterministic survivorship group, Other life table functions, assumptions for fractional ages, Some analytical laws of mortality, Some analytical laws of mortality, Select and ultimate tables.

[12 Lectures]

Unit IV: Life Insurance:

Insurances payable at the moment of death, Level benefit insurance, Endowment insurance, Deferred insurance, Varying benefit insurance, Insurances payable at the end of year of death, Relationships between Insurances payable at the moment of death and the end of year of death, Recursion equation, Commutation functions.

[11 Lectures]

Unit V: Life Annuities:

Single payment contingent on survival, continuous life annuities, discrete life annuities, life annuities with mthly payments, commutation function formulas for annuities with level payments, varying annuities, recursion equations, complete annuities-immediate and apportionable annuities-due. [12 Lectures]

Unit VI: Net Premiums or Benefit Premiums

The random future loss under an assurance or annuity contract, State the principle of equivalence, Notations and formulae of net premium for common life insurance contracts, Fully Discrete Premiums, True monthly payment premium, Commutation functions, Increasing and decreasing Benefit premiums, Profits contract, Types of bonus, Calculating net premiums for with-profit contracts. [12 Lectures]

Recommended Text Books:

[1] Robin Cunningham, Thomas N. Herzog, L. Richard, *Models for Quantifying Risk*, 4th Edition, ACTEX Publications, (2011).

[2] Browers, Newton L et al., *Actuarial Mathematics,* 2nd Society of Actuaries, (1997).

[3] Dickson, C. M. David, Hardy, R. Mary and Waters, R. Howard, *Actuarial Mathematics for Life Contingent Risks*, International series on actuarial science, Cambridge (2009).

[4] S. R. Deshmukh, *An Introduction to Actuarial Statistics*, University Press, (2009).

[5] V. K. Rohatgi and Ehsanes Saleh A. K. MD, *An Introduction to Probability Theory and Mathematical Statistics*, (Wiley Eastern, 2nd Ed.) (2003).

MT-405: Lab Course-IV

Practicals based on courses: MT-402, MT-403, MT-404 using MATLAB
List of Practicals:

1. **Evaluation of Laplace transforms.**
2. **Evaluation of Fourier integrals.**
3. **Evaluation of Fourier transforms.**
4. **Evaluation of Mellin transforms.**
5. **Evaluation of Z transforms.**
6. **Solution of first order difference equations**

Unit I: Symbolic Processing with MATLAB and Modelling Through Integral Transforms:
Symbolic expressions and algebra, Algebraic and transcendental equations, Calculus, Differential equations, Laplace transforms, Fourier integral and transforms, Hankel and Mellin transforms and Symbolic linear algebra.
Unit II: Modelling Through Z-Transform and Difference Equations:
Unit III: Introduction to LaTeX

Recommended Text Books:

[1] William J. Palm III, *Introduction to MATLAB for Engineers,* McGraw-Hill, International Edition (2001).
[2] J. N. Kapur, *Mathematical Modelling,* Wiley Eastern Limited, New Delhi ().
[3] *Partial Differential Equation Toolbox User's Guide,* The MathWorks, Inc. (1984 - 1997).
[4] *Optimization Toolbox User's Guide,* The MathWorks, Inc. (1990 - 2001).
[5] LaTeX Tutorials, Indian TEX User Group, Trivandrum, India