SHIVAJI UNIVERSITY, KOLHAPUR.

Accredited By NAAC with 'A' Grade
Revised Syllabus For

M. Phil./ Ph. D. Course Work

Mathematics

Syllabus to be implemented from
June, 2020 onwards.

List of papers

Compulsory Papers

Paper I: Research Methodology

Paper II: Recent Trends in Mathematics

Optional papers: Paper III

1. Theory of Fractional Dynamic Systems
2. Differential and Integral Inequalities
3. Delay Differential Equations
4. Iterative Methods
5. Topics in Geometric Function Theory
6. Sturm Liouville Theory
7. Generalised Integral Transformations
8. Fuzzy Relations, Graphs, Measures and Integrals
9. Atomistic and Multiplicative Lattices

NEW/REVISED SYLLABUS FOR
M. Phil./Pre Ph. D
(Introduced from June 2020 onwards)
Paper - I
Research Methodology

Unit I: Mathematical Writing: What Is a Theorem?, Proofs, The Role of Examples, Definitions, Notation, Words versus Symbols, Displaying Equations, Parallelism, Dos and Don'ts of Mathematical Writing.
Writing a Paper: Audience, Organization and Structure, Title, Author List, Date, Abstract, Key Words and Subject Classifications. (**15 Lectures**)

Unit II: Writing a Paper (Continued...): The Introduction, Review of Literature, Computational Experiments, Tables, Citations, Conclusions, Acknowledgements, Appendix, Reference List, Specifics and Deprecated Practices.
Revising a Draft: How to Revise, Examples of Prose, Examples Involving Equations, Examples from My Writing, A Revised Proof, A Draft Article for Improvement. (**15 Lectures**)

Unit III: Publishing a Paper: Choosing a Journal, Submitting a Manuscript, The Refereeing Process, How to Referee, The Role of the Copy Editor, Checking the Proofs, Copyright Issues, SIAM Journal Article: A case study.
Writing and Defending a Thesis: The Purpose of a Thesis, Content, Presentation, The Thesis Defence.
(**15 Lectures**)

Unit IV: Quality indices of research publication: impact factor, H- index, science citation index.
Using web for literature review: Google Scholar, Scopus, MathSciNet.
Latex and Beamer for paper typing and presentations: Latex -Typesetting Mathematics, Typesetting Theorems. Making Presentations with LATEX-Beamer. (**15 Lectures**)

References:

1. Higham Nicholas J., Handbook of writing for the mathematical sciences, SIAM, 1961.
2. Stegmann J., How to evaluate journal impact factors, Nature, 390(6660), (1997), 550-550.
3. Kaltenborn K. F. and Kuhn K, The journal impact factor as a parameter for the evaluation of researchers and research, Revista Espanola de Enfermedades Digestivas, 96(7), (2004), 460-476.
4. Hirsch J. E., An index to quantify an individual's scientific research output, https://arxiv.org/abs/physics/0508025
5. Garfield E., The evolution of the Science Citation Index, International Microbiology, 10, (2007), 65-69. DOI: 10.2436/20.1501.01.10
6. LATEX Tutorials A Primer, Indian TEX Users Group, Trivandrum, India, 2003 September.
https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf
7. Tantau T., Wright J. and Miletić V., The beamer class: User Guide for version 3.42, *Published as part of the beamer package* (2015).
http://ctan.imsc.res.in/macros/latex/contrib/beamer/doc/beameruserguide.pdf
8. Hoff Katharina, LATEX-beamer Course, (2007). http://gobics.de/katharina/beamer-script.pdf

Additional Readings:

1. A Primer of Mathematical Writing, Steven G. Krantz, Universities Press Hyderabad 1998.
https://arxiv.org/pdf/1612.04888.pdf
2. McGraw-Hill's Concise Guide to Writing Research Papers, Carol Ellison, McGraw-Hill, New York, 2010.

NEW/REVISED SYLLABUS FOR
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Paper: II
Title of Paper: Recent Trends in Mathematics

Unit I: Notation and Terminology, Some Linear Algebra, Some Complex Analysis, Some Results from Real Analysis, Review of Functional Analysis, Special Classes of Operators, Weak Topologies, Banach-Alaoglu Theorem, Banach space valued analytic functions, Dunford's Theorem on the weak Analyticity. **15 Lectures**

Unit II: Banach Algebras, The Spectrum, Compactness of the Spectrum, The Spectral Radius Formula, The Spectral Mapping Theorem for Polynomials and Analytic functions, The Analytic Functional Calculus, Spectral Localization Theorem and its Applications, The Spectral Projection, Positive Operators, Partial Isometries, The Square Root Lemma and the Polar Decomposition. **15 Lectures**

Unit III: Compact Operators, Finite Approximal Operators, Completely Continuous Operators, Spectral Theorem for Compact Self Adjoint Operators, The Hilbert- Schmidt Spectral Theorem for Compact Normal Operator, The Riesz-Schauder Spectral Theorem for general Compact Operators on Banach Spaces, Fredhom Alternative, Weak Lomonosov Theorem, Ringrose-West Decomposition. **15 Lectures**

Unit IV: Ringrose Structure Theorem, C*-Algebras, Gelfand Transform, Gelfand-Naimark Theorem for Commutative C*-Algebras, The Spectral mapping Theorem for Continuous functions, Continuous Functional Calculus, Spectral Measure, The Spectral Theorem for Normal Operators ,Borel Functional Calculus. **15 Lectures**

Recommended Books:

1. Barry Simon, Operator Theory-A Comprehensive Course in Analysis- Part 4, American Mathematical Society, Providence, Rhode Island , 2015.
2. Kehe Zhu, An Introduction to Operator Algebras, CRC Press, 1993.

Reference Books:

1. John B. Conway, A course in Operator Theory, (Graduate Studies in Mathematics, Vol. 21) American Mathematical Society, Providence, Rhode Island , 1999
2. John B. Conway, A Course in Functional Analysis, Second Edition, Springer-Verlag, New York 1990.
3. Walter Rudin, Functional Analysis , Second Edition, McGraw-Hill, 1990.
4. S. K. Berberian, Lectures in Functional Analysis and Operator Theory, Springer- Verlag, New York, 1974.
5. Balmohan V. Limaye, Functional analysis, New Age International, New Delhi, 1996.

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Paper: III(1)
Title of Paper: Theory of Fractional Dynamic Systems

Unit I: A Short History and Some Related Functions, The R-L Fractional Integrals and Derivatives, The Grunwald-Letnikov Derivative, The Caputo Derivative, The Mean Value Theorem, Dini Derivatives and Comparison Theorems, The Volterra fractional integral inequalities, Fractional Differential inequalities Local Existence and Extremal Solutions, Existence, Uniqueness and Continuous Dependence.

15 Lectures

Unit II: Approximate Solutions and Global Existence, Linear Fractional Differential Equations, Finite Systems of Differential Inequalities, Existence of an Euler Solution, Caputo's Fractional Differential Equation,Theoretical Approximations-Theoretical and Constructive Existence Result, Generalized Monotone Iterative Technique, Monotone Method for PBVP, Generalized Monotone Iterative Technique- PBVP. **15 Lectures**

Unit III: Quasilinearization,Generalized Quasilinearization, Stability Criteria,Proximal Normal and Flow Invariance,Relation Between Fractional and Ordinary DEs, Lyapunov Theory -Basic Comparison Result, Stability Criteria,Stability Concepts in Terms of Two Measures,Stability Criteria in Terms of Two Measures,Boundedness and Lagrange Stability. **15 Lectures**

Unit IV: Several Lyapunov Functions,Multi-Order Fractional Differential Systems, Stability of Multi-Order Systems via ODEs, Fractional Functional DEs, Fractional DEs Involving Causal Operators, and Fractional DEs in a Banach space, Nonlocal Boundary Value Problems, BVP for Fractional Differential Inclusions, Almost Automorphic Solutions of Evolution Equations.

15 Lectures

Recommended Book(s):

1. V. Lakshmikantham, S. Leela and J. Vasundhara Devi, Theory of Fractional Dynamic Systems, Cambridge Scientific Publishers, UK, 2009.

Reference Books:

1. Igor Podlubny, Fractional differential equations. San Diego: Academic Press; 1999.
2. A. Kilbas, H.M. Srivastava, J.J. Trujillo, Theory and Applications of Fractional Differential Equations, Elsevier, Amsterdam, 2006.
3. Kai Diethelm, The Analysis of Fractional Differential Equations, Springer, 2010.
4. L. Debnath, D. Bhatt, Integral Transforms and Their Applications, CRC Press, 2010.

NEW/REVISED SYLLABUS FOR
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Paper: III(2)
Title of Paper: Differential and Integral Inequalities

Unit I: Existence and continuation of solutions, Scalar differential inequalities, Maximal and minimal solutions, Comparison theorems, Finite systems of differential inequalities, Minimax solutions, Integral inequalities reducible to differential inequalities, Differential inequalities in the sense of Caratheodory **15 Lectures**

Unit II: Global existence, Uniqueness, convergence of successive approximations, Chaplygin's method, Dependence on initial conditions and parameters, Variation of constants, Upper and lower bounds, Componentwise bounds, Asymptotic equilibrium, Asymptotic equivalence. Stability criteria, Asymptotic behavior **15 Lectures**

Unit III: The inequalities of Gronwall and Bellman, Some generalizations of the Gronwall-Bellman inequality, Volterra-type integral inequalities, The inequalities of Gamidov and Rodrigues, Simultaneous inequalities, Pachpatte's inequalities, Integro-differential inequalities, Applications-Second order integro-differential equations, Perturbation of Volterra integral equations, Higher order integro-differential equations **15 Lectures**

Unit IV: Nonlinear integral inequalities-Inequalities involving comparison, The inequalities of Bihari and Langenhop, Generalizations of Gronwall- Bellman- Bihari inequalities, Inequalities with Volterra-type kernels, Inequalities with nonlinearities in the integral, Pachpatte's inequalities I, Pachpatte's inequalities II, Integro-differential inequalities, Applications-Second order nonlinear differential equations, Perturbed integro-differential equations **15 Lectures**

Recommended Book(s):

1. V. Lakshmikantham, S. Leela, Differential and integral inequalities -Theory and applications*, Vol-I, Accademic Press, New York London, 1969.*
2. B. G. Pachpatte, Inequalities for differential and integral equations, *Accademic Press, London ,1998.*

Reference Books:

1. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw-Hill, 1955.
2. B. G. Pachpatte, Integral And Finite Difference Inequalities and Applications, North-Holland Mathematics Studies 205, 2006
3. M. Hirsch, S. Smale and R. L. Devaney, Differential equations, dynamical systems and an introduction to chaos, Elsevier Academic Press, USA, 2004.
4. S. G. Deo, V. Lakshmikantham, V. Raghvendra, Textbook of Ordinary Differential Equations, Tata McGraw-Hill, 1997.

REVISED SYLLABUS FOR
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Paper: III(3)
Title of Paper: Delay Differential Equations

Unit I: Linear differential difference equations: Differential and difference equations, Retarded differential difference equations, Exponential estimates, The characteristic equation,The fundamental solution, The variation-of-constants formula, Neutral differential difference equations.
Retarded functional differential equations: Definition, Existence, uniqueness, and continuous dependence, Continuation of solutions, Differentiability of solutions. **15 Lectures**

Unit II: Stability theory: Definitions, The method of Liapunov functionals, Liapunov functionals for autonomous systems
Nonlinear Delay Differential Equations, Salient Features of Chaotic Time-Delay Systems, Linear Stability Analysis **15 Lectures**

Unit III: A Geometric Approach to Study Stability, A General Approach to Determine Linear Stability of Equilibrium Points.
Bifurcation and Chaos in Time-Delayed Piecewise Linear Dynamical System: Simple Scalar First Order Piecewise Linear DDE, Numerical Study of the Single Scalar Piecewise Linear Time-Delay System **15 Lectures**

Unit IV: A Few Other Interesting Chaotic Delay Differential Equations: The Mackey-Glass System, Ikeda Time-Delay System, Scalar Time-Delay System with Polynomial Nonlinearity, Scalar Time-Delay System with Other Piecewise Linear Nonlinearities, Time-Delayed Chua's Circuit **15 Lectures**

Recommended Book(s):

1. Hale, Jack K., Theory of functional differential equations, Springer-Verlag Berlin Heidelberg 1928
2. M. Lakshmanan, D.V. Senthilkumar, Dynamics of Nonlinear Time-Delay Systems, Springer-Verlag Berlin Heidelberg 2010.

Reference Books:

1. Hal Smith, An Introduction to Delay Differential Equations with Sciences Applications to the Life, Springer New York, 2011.

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Paper - III(4)
Iterative Methods

Unit I: Adomian Decomposition Method (ADM): The ADM for solving differential equations, convergence of ADM, ADM in several dimensions, Solving boundary value problems using ADM. (**15 Lectures**)

Unit II: Modified ADM, Mathematica code of ADM.

Daftardar-Gejji and Jafar Method (DJM): The DJM for solving nonlinear equations, convergence of DJM, comparison of ADM and DJM, Applications of DJM for generating new numerical methods for solving algebraic equations and differential equations, Mathematica code of DJM. (**15 Lectures**)

Unit III: Homotopy Perturbation Method (HPM): The HPM algorithm, convergence analysis, applications.

Homotopy Analysis Method (HAM): The HAM algorithm, convergence analysis, the role of auxiliary parameter, control of convergence, relation to ADM and HPM. (**15 Lectures**)

Unit IV: Applications of HAM to solve nonlinear equations.

Variational Iteration Method (VIM): The VIM algorithm, convergence of VIM, applications to solve ordinary differential equations**.**

Solving system of fractional differential equations using ADM**.** (**15 Lectures**)

References:

1. G. Adomian, Solving frontier problems in Physics: The decomposition method, Kluwer Academic Publishers, London, 1994.
2. K Abbaoui and Y Cherruault, Convergence of Adomian's method applied to differential equations, Math Comput Model, 28 (5) (1994), 103-109.
3. A. M. Wazwaz, A reliable modification of Adomian decomposition method, Applied Mathematics and Computation, 102(1) (1999), 77-86.
4. V. Daftardar-Gejji and H. Jafari, An iterative method for solving nonlinear functional equations, Journal of Mathematical Analysis and Applications, 316(2) (2006), 753-763.
5. S. Bhalekar and V. Daftardar-Gejji, Convergence of the new iterative method, International Journal of Differential Equations, 2011 (2011).
6. K. Noor and M. Noor, Iterative methods with fourth-order convergence for nonlinear equations, Applied Mathematics and Computation, 189 (1) (2007), 221–227.
7. V. Daftardar-Gejji, Y. Sukale and S. Bhalekar, A new predictor-corrector method for fractional differential equations, Applied Mathematics and Computation, 244 (2) (2014), 158–182.
8. J. H. He, Homotopy perturbation method: a new nonlinear analytical technique, Applied Mathematics and computation, 135(1) (2003), 73-79.
9. Z. Ayati and J. Biazar, On the convergence of Homotopy perturbation method, Journal of the Egyptian Mathematical Society, 23(2) (2015), 424-428.
9. S. Liao, Beyond perturbation: introduction to the homotopy analysis method, CRC press, 2003.
10. J. H. He, Variational iteration method–a kind of non-linear analytical technique: some examples, International journal of non-linear mechanics, 34(4) (1999), 699-708.
11. Z. Odibat, A study on the convergence of variational iteration method, Mathematical and Computer Modelling, 51(9) (2010), 1181-1192.
12. J. H. He, Variational iteration method for autonomous ordinary differential systems, Applied Mathematics and Computation, 114(2) (2000), 115-123.
13. V. Daftardar-Gejji and H. Jafari, Adomian decomposition: a tool for solving a system of fractional differential equations, Journal of Mathematical Analysis and Applications, 301(2) (2005), 508-

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Paper : III(5)

Title of Paper : Topics in Geometric Function Theory

Specific Objectives : In this course student will be acquainted with concepts of Geometric Function Theory. This is a branch of Complex Analysis with sustained interest for several years.

UNIT: I

Schwarz's Lemma, Montel's Theorem, Green's Theorem on Harmonic functions, Univalent functions, Koebe Functions, Area theorem, Growth and distortion theorems. Brief history of D'Branges theorem, Littlewood's theorem. (15)

UNIT: II

Convex, starlike functions, Alexander's theorem, Close to convex functions, Noshiro-Warchawski's theorem, Kaplan's theorem. Spirallike functions, Radius of starlikeness, convexity and close to convexity. (15)

UNIT III

Differential subordination, Hypergeometric functions, convolution (Hadamard product) Fractional derivatives, coefficient inequalities, closure property. Basic concepts of bi-univalent functions. (15)

UNIT IV

Some Basic Facts of Harmonic Mappings, Harmonic univalent functions, Normalizations Normal Families, The Harmonic Koebe Function, Coefficient Conjectures. (15)

Reference books:

1. P.L.Duren: Univalent Functions, Springer-Verlag, New York, Berlin, Heidelberg,1983.
2. S. S. Miller and P. T. Mocanu, Differential subordinations, Marcel Dekker, Inc., New York-Basel, 1999.
3. P.L. Duren, Harmonic mappings in the plane, Cambridge Tracts in Mathematics, 156. Cambridge Univ. Press, Cambridge, 2004.
4. M. Lewin, On a coefficient problem for bi-univalent functions, Proc. Amer. Math. Soc. 18(1967) 63–68.
5. D.A. Brannan, T.S. Taha, On some classes of bi-univalent functions, S.M. Mazhar, A. Hamoui, N.S. Faour (Eds.), Mathematical Analysis and Its Applications, KFAS Proceedings Series, vol. 3, Kuwait; February 18–21, 1985, Pergamon Press (Elsevier Science Limited),Oxford (1988), pp. 53-60.

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Paper - III(6)

Title of Paper: Sturm Liouville Theory

Specific Objectives: The objective of the paper is to introduce basic Sturm Liouville theory. In this course students will be acquainted with Bessel equations and Bessel functions, Legendre equations and Legendre polynomials, existence and uniqueness of solutions of initial and boundary value problems, Dependence of solutions on initial conditions. Nature of zeros of solutions of Sturm Liouville problems.

(iv) Number of Units: 4

Unit I: Power-series solution of ODEs , The method of Frobenius, The basic method, The two special cases ,The Bessel equation and Bessel functions **,** First solution , The second solution, The modified Bessel equation, Generating functions, Legendre polynomials , Hermite polynomials, Bessel functions.

Unit II : An introduction to Sturm-Liouville theory: Introduction and Background **,**The second-order equations, The boundary-value problem ,Self-adjoint equations , The Sturm-Liouville problem: the Real Simple eigen values, the eigen functions **,**The fundamental oscillation theorem , Orthogonality, Eigen function expansions, Inhomogeneous equations

Unit III: Second-Order Equations , Zeros of Solutions , Self-Adjoint Differential Operator, The Sturm–Liouville Problem, Existence of Eigen functions, Completeness of the Eigen functions , The Singular SL Problem.

Unit IV: Existence and Uniqueness Problems **:** First Order Systems, Existence and Uniqueness of Solutions, Variation of Parameters ,The Gronwall Inequality, Bounds and Extensions to the End points , Continuous Dependence of Solutions on the Problem ,Differentiable Dependence of Solutions on the Data, Adjoint Systems,
Scaler initial value problems: Existence and Uniqueness, Continuous Extensions to the End points ,Continuous Dependence of Solutions on the Problem, Differentiable Dependence of Solutions on the Data, Sturm Separation and Comparison Theorems.

(v) **Recommended Reading** :

a) Basic Reading: Coddington: Ordinary Differential Equation.

b) Additional Reading: Pinsky :Pratial Differential Equations and Boundry Value Problems

3**) References Books:**

1) R.S. Johnson : Second-order ordinary differential equations:Special functions, Sturm-Liouville theory and transforms, R.S. Johnson & Ventus Publishing ApS 2012

2) M.A. Al-Gwaiz: Sturm-Liouville Theory and its Applications . Springer 2008

3) Anton Zettl: Sturm Liouville Theory. American Mathematical Society 2005

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Paper III (7)

Title of the Paper: Generalised Integral Transformations

***Objectives:** The objective of the paper is to introduce Frechet spaces and spaces of generalised functions. In this course, students will be acquainted with Fourier, Laplace transforms on the spaces of generalised functions. Moreover, students will be introduced to Wavelet transform and its applications.

Units:

Unit I: Multinormed Spaces, Countable Union Spaces, Dual of Countably Multinormed Spaces, Operators and Adjoint Operators. The Spaces $D(I)$, and their Duel Spaces, The Space $E(I)$ and its dual, Space of Tempered Functions; Distributions of Compact support, Generalised Functions with counter examples (No. of Lectures 15)

Unit II: Schwartz's Space, The testing Function Spaces $L_{a,b}$ and $L(w,z)$ and their duals, Two sided Laplace Transformation, Fourier transform, Transform Formulas, Inversion and uniqueness, An operational calculus, Convolution, Laplace and Fourier transforms of convolution. (No. of Lectures 15)

Unit III: Testing Function spaces A, Generalised function space A', Orthonormal Series Expansions and Generalised integral transformations, Characterisation of the Generalised functions in A' and their transforms, An operational calculus for the operator R. (No, of Lectures 15)

Unit IV: Introduction to Wavelet transforms, Practical Resolutions, Gain, and processing structures, wavelet theory and Ambiguity functions. Applications of Wavelet transform. (No. of Lectures 15)

Recommended Reading:

1. Zemanian A. H., Generalised Integral Transformations, John Wiley and Sons (1968)
2. Pathak R. S., Integral Transforms of Generalised Functions and Applications
3. Ian N. Sneddon, Use of Integral transforms, McGraw Hill, Second Printing edition (1972)
4. Randy K. Young, Wavelet Theory and Its Applications, The Springer International Series of engineering and Computer Sciences.

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Paper: III (8)
Title of Paper: Fuzzy Relations, Graphs, Measures and Integrals

Specific Objectives: In this course student will be acquainted with concepts of Fuzzy Relations, Fuzzy Graphs, Fuzzy Measures and Fuzzy Integrals.

Number of Units: 4

UNIT I: FUZZY RELATIONS:

Fuzzy Relations, Operations on Fuzzy Relations, Reflexivity, Symmetry and Transitivity, SUP-I compositions and inf-wi compositions. fuzzy Relation Equation:Problem Partitioning, solution methods, Fuzzy relational equations based on sup-I and inf-wi compositions, Approximate solutions . (No of Lectures 15)

UNIT II: APPROXIMATE REASONING.

Approximate Reasoning: - Fuzzy expert systems, Fuzzy implications, selection of Fuzzy implications, Multi-conditional Approximate Reasoning, Role of fuzzy relational equations, Interval valued

(No of Lectures 15)

UNIT-III: FUZZY GRAPHS

Paths and Connectedness, Clusters, Cluster Analysis and Modeling of Information Networks, Connectivity in Fuzzy Graphs, Application to Cluster Analysis, Operations on Fuzzy Graphs, Fuzzy Intersection Equations, Fuzzy Graphs in Database Theory.

(No of Lectures 15)

UNIT-IV: FUZZY MEASURES AND INTEGRALS

Fuzzy measures, Evidence theory, possibility theory, Fuzzy sets and possibility theory, possibility theory verses probability theory Uncertainty based Information: -Information and Uncertainty, Non specificity, of crisp sets and fuzzy sets fuzzyness of fuzzy sets, uncertainty in Evidence theory, uncertainty measures, of uncertainty. Fuzzy measures as Non additive measures, Sugeno integrals and its properties, Choquet integral, Fuzzy integrals as an aggregation oprators. Applications to multicriteria Decision Making.

(No of Lectures 15)

(v) Recommended Reading:

a) Basic Reading:

1: George J Klir, Bp yuan, Fuzzy sets and Fuzzy Logic. Theory and applications, Prentice-Hall of India. Pvd .Ltd.(2000)

2: M.Grabish, Sugeno, and Murofushi Fuzzy Measures and Integrals: theory and Applications PHI, 1999, India.

3: H.J.Zimmerermann, fuzzy set Theory and its Applications, Kluwer, 1984.

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Paper: III (9)
Title of paper: Atomistic and Multiplicative Lattices

UNIT I : (No of Lectures 15)
Lattices, modular lattices, distributive lattices, Boolean Algebra product of lattices.

UNIT II: (No of Lectures 15)
Symmetric Lattice and basic Properties of lattices: Modularity in Lattices Semi-orthogonality in lattices, orthogonality in lattices in Symmetric Lattices, Distributivity and the Center of a Lattice, center of Complete Lattices, Perspectivity and projectivity in Lattices.

UNIT III: (No of Lectures 15)
Atomistic Lattices and the Covering Property: The Covering Property in Atomistic Lattices, Atomistic Lattices with the Covering Property, Finite-Modular AC-Lattices, Distributivity and Perspectivity in Atomistic Lattices, Perspectivity in AC- Lattices, Completion by cuts.

UNIT IV: (No of Lectures 15)
Multiplicative Lattices : Definition Principal , Quotients Lattices, Noetherian Lattices

a) Basic Reading:
1. Theory of Symmetric Lattices, F. Maeda and S. Maeda,Spriinger-Verlag,1970
2. Lattice Theory: First Concepts and Distributive Lattices, George A. Gratzer, Dover Publications Inc.
3. The Congruences of a Finite Lattice: A "Proof-by-Picture" Approach, George A. Gratzer, Springer Nature; 2014 edition
4. General Lattice Theory, George A. Gratzer, Academic Press.
5. Binary Quadratic Forms, Johannes Buchmann Ulrich Vollmer, Springer .
6. A Guide to the Literature on semirings and their Applications in Mathematics and Information Sciences, Kazimierz Gtazek, Springer