PHD COURSE WORK SYLLABUS

Pre PhD Course Work

in Mathematics

(Effective from the Academic Session 2021-2022)

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

Maharaja Bir Bikram University

College Tilla, P.O: Agartala College
Agartala, Tripura
Pin Code: 799004

Department of Mathematics

PhD Course Work syllabus structure of the Department of Mathematics, MBB University
(with effect from 2021-2022)

Course Code	Course Title	Credit	Full marks
MATH-501	*Research methodology - I*	4	100
MATH-502	*Research methodology - II*	4	100
MATH-503	*Fuzzy set and Fuzzy topology*	4	100
MATH-504	*Advanced Operations Research*	4	100
MATH-505	*Nonlinear Dynamics and Mathematical Modelling*	4	100
MATH-506	*Project Work*	4	100

Note: PhD Scholars have to choose any one of the course from MATH-503, MATH-504 and MATH-505.

Research Methodology-I
MATH -501
Full Marks: 100
Credit: 4

Definition of Research: What is Research? Types of Research. What is a problem? Necessity of defining problem, Technique involved in defining a problem. Objective of a Research. Significance of a Research Work. What is Methodology? Requirements for the Success as a Researcher.

Research Methods: Discovery and verification, Choosing a Problem, Concept Formation, Resources are converted into properties, Observation and Theory, Analysis, simulations and experiments, Techniques involved in solving the problem: Different methods used to solve a problem.

Research Design: Subject of study; Place of study; Reason of such study; Type of data required; Method of data collection; Periods of study; Style of data presentation.

Developing a Research Plan: Research objective; Information required for solving the problem; Each major concept should be defined in operational terms; An overall description of the approach should be given and assumption if considered should be clearly mentioned in research plan; The details of techniques to be adopted.

Methods of Data Collection: Experimental methods.

Analysis of Data: Various measures of relationship often used in research studies, Correlation coefficients. Probability Distribution.

Curve Fitting: Linear and Non-linear fitting of data.

Computer Applications: Knowledge of Word, Excel, Document preparation, Power point Preparation, Internet (Papers from Google searching etc.), Latex. C-program: Basic numerical programs.

Error Analysis: Basics of a measurement and its interpretation, mean, standard deviation, variance, correlation coefficient; Usage of packages (e.g. ORIGIN; EXCEL) for data analysis.
** Any other relevant topic may be incorporated.

References:

1. **C. R. Kothari**, *Research Methodology: Methods and Techniques, 2nd edition*, ***New Age International Publishers***.
2. **Donald R. Cooper**, **Pamela Schindler**, *Business Research Methods, 9th Edition*, ***Tata McGraw Hill***.
3. **Paul Ernest,** *The Philosophy of Mathematics Education*, ***Springer***.
4. **E. Balaguruswamy**, *Programming with ANSI-C*, ***Tata Mc-Graw Hill***.
5. **Sheldon M. Ross,** *Probability and Statistics, **Elsevier***.

Research Methodology-II

MATH - 502

Full Marks: 100

Credit: 4

Review and critic of published research in a relevant field, training, field work, communication skill.

Writing of Research Papers.

Fuzzy Set and Fuzzy Topology
MATH -503
Full Marks: 100
Credit: 4

Fuzzy set: Characteristic function and definition of fuzzy sets, Fuzzy point, α - level set, convex fuzzy sets, basic operations on fuzzy sets. Cartesian products, algebraic products, bounded sum and difference, t – norms and t - conforms, quasi coincidence of two fuzzy subsets.

Generalization and variants of fuzzy sets: L fuzzy sets, interval valued fuzzy sets, Type 2 fuzzy sets, intuitionistic fuzzy sets and set operation of intuitionistic fuzzy sets. The Zadeh's extension principal.

Fuzzy arithmetic: Fuzzy numbers, triangular fuzzy numbers, Fuzzy numbers describing 'large', Fuzzy numbers in the set of integers, Arithmetic operation on interval and fuzzy numbers.

Fuzzy relation and fuzzy graph: Fuzzy relations on fuzzy sets, composition of fuzzy relations, Max min and min max composition, basic properties of fuzzy relations.

Fuzzy order: Fuzzy preorder and fuzzy order relations, fuzzy equivalence relation, fuzzy compatibility relations, fuzzy graph, fuzzy similarity relations, examples of different fuzzy relations.

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

Fuzzy Matrix: Sum, multiplication of two fuzzy matrices, Idempotent fuzzy matrix and their properties.

Fuzzy Topology: Chang's definition and Lowen's definition, lower semi continuous function, fuzzy closure, fuzzy interior, induced fuzzy topological space.
** Any other advancement in these fields can be incorporated.

References:

1. **H. J. Zimmermann**: *Fuzzy Set Theory and its Applications*, ***Allied Publishers Ltd***.
2. **G. J. Klir and B Yuan**: *Fuzzy Sets and Fuzzy Logic*, ***Prentice Hall of India***.
3. **G Bozaqdziev and M Bojadziev**: *Fuzzy sets, Fuzzy Logic, Applications*, ***World Scientific***.
4. **N. Palaniappan**, *Fuzzy Topology*, ***Narosa***.
5. **A. Mukherjee and S. Bhattacharya Halder**, *Fuzzy Set and Fuzzy Topology*, ***Narosa***.
6. **H. J. Zimmermann**: *Fuzzy Set Theory and its Applications*, ***Springer***.

Advanced Operations Research
MATH-504
Full Marks: 100
Credit: 4

Non linear programming: Some definitions, Graphical illustration of NLP, Khun-Tucker Conditions and its applications, Quadratic programming, convex programming.

Game Theory: Introduction to game theory, strategies, costs and payoffs, Prisoner's dilemma, Nash equilibrium, strategic games, Dominant strategies, Pure strategy, Mixed strategy, Repeated games, Non-cooperative games, Cooperative game theory, Fuzzy game problem.

Queueing systems: Stochastic processes and Markov chains (Discrete Time Markov Chains and Continuous Time Markov Chains), Characteristics of queueing systems, Markovian and non-Markovian queueing systems, Transient behaviour; Different types of Queueing Systems. Applications of the queueing theory to the performance modeling of computer and communication networks.

Inventory Management: Deterministic and probabilistic inventory models in different situations.

Fuzzy set and Fuzzy logic: An over view, applications in decision making problem.

** Any other advancement in the field can be incorporated.

References:

1. **S.D. Sharma**. *Operations Research. Kedar Nath Ram Nath*.
2. **Kanti Swarup, P.K. Gupta and Manmohan**: *Operations Research*, *S. Chand.*
3. **H.S. Taha**: *Operations Research, Pearson.*
4. **J.K. Sharma**, *Operations Research*: *theory and application*, *Macmillan Publishers*.
5. **Eliczer Nadder**, *Inventory Systems*, *John Wiley and Sons.*
6. **M.J. Osborne, A. Rubistein**, *A course in Game Theory*, *MIT Press.*

Nonlinear Dynamics and Mathematical Modelling
MATH-505
Full Marks: 100
Credit: 4

Linear and Nonlinear Systems of Ordinary Differential Equations: Properties of Solutions, Phase Portraits, Linearization Techniques, Stability of the Equilibrium Points, *Hartman's* Theorem, *Liapunov's* Method of Global Stability, *Lasalle's* Invariance Principle Non-Autonomous Systems, Seasonality. Translation Property, Limit Set, Attractors, Periodic Orbits, Limit Cycles And Separatrix, *Bendixon*'s Criterion, *Dulac* Criterion, *Poincare-Bendixon* Theorem (In n Dimensional System), *Muldowny's* Lemma, Index of a Point, Index at Infinity. *Any other advances in the field of Differential equations.*

Bifurcation Theory: Existence Conditions and Nature of various bifurcations like: *saddle-node, transcritical, pitchfork, Hopf, Bogdanov-Taken's* etc., *Chaos Theory*, *Lorenz* system and the *Butterfly Effect. Any other advances in the field of Bifurcation Theory.*

Linear and Nonlinear Difference Equations: Properties of Solutions, Steady States and their stability, Bifurcations, Period Doubling, k-cycles, *Feigenbaum's* Number, *Lyapunov Exponents*, *Rosselor* System, *Henon* System, *Logistic* Map Etc., Transformation of Deterministic Systems to Discrete Systems. *Any other advances in the field of Difference Equations.*

Linear and Nonlinear Delay Differential Equations: Definitions and Notations, Applications, Solution, Stability Analysis of Systems of Delay Differential Equations, Analysis of Characteristic Equations with Delay Dependent Coefficients. *Any other advances in the field of Delay Differential Equations.*

Stochastic Differential Equations: Definitions and Notation, Random Walk and Brownian Motion, White and Color Noise, Diffusion Process, Kolmogorov Differential Equations, Wiener Process, Ito Stochastic Integral, Ito Stochastic Differential Equation. *Any other advances in the field of Stochastic Differential Equations.*

Numerical Simulation Techniques and Mathematical Software: MATLAB/XPP-Auto/R/Mathematica. *Any other relevant software.*

Mathematical Modelling: Need, Techniques, Classifications, Mathematical Modelling using systems of Ordinary Differential Equations, Difference Equations, Stochastic differential Equations, Partial Differential Equations, Delay Differential Equations, Diffusion and pattern Formation, Optimal Control and Optimization Theory. *Any other advances in the field of Mathematical Modelling.*

** Any other advancement in these fields can be incorporated.

References:

1. **L. Perko**, *Differential Equations and Dynamical Systems,* ***Springer (India).***
2. **S. Elaydi**, *An Introduction to Difference equations, Springer.* ***Springer (India)***
3. **Rudra Pratap**, *Getting started with MATLAB,* ***Oxford University Press***.
4. **Steven Strogatz,** Nonlinear Dynamics and Chaos, *Levant*
5. **Linda J S Allen,** An Introduction to Stochastic Processes, *CRC Press*.
6. **K. Gopalaswamy,** Stability and Oscillations in Delay Differential Equations of Population Dynamics, ***Springer.***

Project Work
MATH-506
Full Marks: 100
Credit: 4

Select one topic of the related research field.