School of Physical Sciences (Mathematics)

DIT University Dehradun

Course Structure & Syllabus for Pre Ph.D. (Mathematics) Course Work

Session: 2020-21

Approved by the Academic Council at its 14th Meeting held on 20.04.2020

Pre-Ph.D. (Mathematics)

Course Category	Course Code	Course Name	Periods			Credits
			L	T	P	
UC	MB901	Research Methods	4	0	0	4
-	CPE-RPE	Research Publication Ethics	2	0	0	2
DC	MA601	Advanced Mathematics	4	0	0	4
DE		Elective 1	4	0	0	4
DE		Elective 2	4	0	0	4
DC	DS001	Seminar	1	0	0	1
		Total				**19**

List of Elective 1		
S. No.	**Course Code**	**Course Title**
1	MA747	Fuzzy Sets and Applications
2	MA749	Mathematical Modelling and Simulations
3	MA757	Numerical Solution of PDE's
5	MA759	Dynamical Systems
List of Elective2		
4	MA758	Integral Equations & Calculus of Variations
6	MA766	Magneto hydrodynamics
7	MA767	Thermal Instabilities and Methods
8	MA768	Statistical Techniques
9	CS753	Distributed System

Note : Apart from above listed Elective courses, Research Scholar may choose any course across departments being offered at PG level, if it is required/suggested by the Research Committee.

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<table>
<tr><td>Subject Code</td><td>MB901</td><td>Subject Title</td><td colspan="7">RESEARCH METHODOLOGY</td></tr>
<tr><td>L T P</td><td>3 1 0</td><td>Credit</td><td>4</td><td>Subject Category</td><td>Univ. Core</td><td>Year</td><td>1st</td><td>Semester</td><td>I</td></tr>
</table>

OBJECTIVE: Students of the course should master properties of matrices including how to use them to solve linear systems of equations and how they are used in linear transformations between vector spaces.

Unit I Fundamentals of Research

Defining research, Objectives of research, types, research process, deductive and inductive reasoning;

Identifying and formulating a research problem, Literature review: Search for existing literature (World Wide Web, Online data bases), Review the literature selected (Case studies, review articles and Meta-analysis), Develop a theoretical and conceptual framework, Writing up the review,

Definition of variables : Concepts, indicators and variables, Types of variables, Types of measurement scales, Constructing the Hypothesis- Null(Research) and alternative, one-tailed and two-tailed testing, errors in testing. Ethical and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights

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Unit II Research Design

Design of Experiments: Research Designs -Exploratory, Descriptive and Experimental, Experimental designs- Types of Experimental Designs

Unit III Sampling, Sampling distribution, and Data Collection

Sampling distribution, Normal and binomial distribution, Reasons for sampling, sampling technique, sampling errors. Sources of Data-Primary Data, Secondary Data, Data Collection methods.

Unit IV Statistical Data Analysis

Descriptive and inferential statistical analysis. Testing of hypothesis with Z-test, T-test and its variants, Chi-square test, ANOVA, Correlation, Regression Analysis, Introduction to data analysis data using SPSS20.0

Unit V Research Report

Writing a research report- Developing an outline, Formats of Report writing, Key elements- Objective, Introduction, Design or Rationale of work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and various formats for reference writing of books and research papers, Writing a Research Proposal.

Recommended Books:

1. C.R.Kothari, “Research Methodology”, 5th edition, New Age Publication,
2. Ganesan R, Research Methodology for Engineers , MJP Publishers, Chennai. 2011
3. Cooper, “Business Research Methods”, 9th edition, Tata McGraw hills publication
4. Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2007.
5. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
6. Bordens K.S. and Abbott, B.b.: Research Design and Methods, Mc Graw Hill, 2008.
7. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197 -222; 391 – 403.

Pre-Ph.D. (Mathematics)

Subject Code	MA601	Subject Title	ADVANCED MATHEMATICS						
L T P	3 1 0	**Credit**	4	**Subject Category**	Univ. Core	**Year**	1	**Semester**	I

Course Objective:

1. The aim is to teach the student various topics in Numerical Analysis such as solutions of nonlinear equations in one variable, interpolation and approximation, numerical differentiation and integration, direct methods for solving linear systems, numerical solution of ordinary differential equations.
2. Introduce students to how to solve linear Partial Differential with different methods. To derive heat and wave equations in 2D and 3D. Find the solutions of PDEs are determined by conditions at the boundary of the spatial domain and initial conditions at time zero.
3. The objective of this course is to provide an understanding for the graduate business student on statistical concepts to include measurements of location and dispersion, probability, probability distributions, sampling, estimation, hypothesis testing, regression, and correlation analysis, multiple regression and business/economic forecasting.
4. To determine properties of Legendre Polynomial which may be solved by application of special functions.
5. To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems. Ability to determine the starting point to initiate the simplex method

Unit I: **Numerical Techniques**

Zeros of Transcendental and Polynomial equation using bisection method, Newton-Raphson method, Rate of convergence of above methods. Interpolation: Finite differences, difference tables, Newton's Forward and Newton's Backward Interpolation, Lagrange's and Newton divided difference formula for unequal intervals. Solution of system of Linear equations, Gauss- Seidal method, Crout method. Numerical Integration: Trapezoidal rule, Simpson's one-third rule, Simpson's three-eighth rule, Solution of ordinary differential (first order, second order and simultaneous) equations by Picard's and Fourth order Runga - Kutta methods

Unit II: **Partial Differential Equations (PDE)**

Formation and Classification of PDE, Solution of One Dimension Wave Equation, and Heat Equation, Two Dimension Heat and Laplace Equation by Separation of variables Method.

Unit III: **Special Functions**

Series solution of ODE of 2nd order with variable coefficient with special emphasis to Legendre and Bessel differential equation, Legendre polynomial of first kind, Bessel Function of first kind and their properties.

Unit IV: **Statistics**

Elements of statistics, frequency distribution: concept of mean, median, mode, Standard derivation , variance and different types of distribution: Binomial, Poisson and Normal distribution, curve fitting by least square method, Correlation and Regression, Concept of Hypothesis Testing.

Unit V: Optimization

Formulation, Graphical method, Simplex method, Two-Phase simplex method, Duality, Primal- dual relationship, Dual-simplex method.

Learning Outcomes

By the end of the course the student is expected to solve real-life and Engineering applications reflecting the student ability to:

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CO1. Recognize and apply appropriate theories, principles and concepts relevant to Numerical Analysis. Critically assess and evaluate the literature within the field of Numerical Analysis. Analyze and interpret information from a variety of sources relevant to Numerical Analysis.

CO2. Solve linear partial differential equations of both first and second order. Apply partial derivative equation techniques to predict the behavior of certain phenomena. Apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialization.

CO3. To calculate and apply measures of location and measures of dispersion -- grouped and ungrouped data cases and to apply discrete and continuous probability distributions to various business problems. Also make them able to perform Test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases.

CO4. To explain the applications and the usefulness of the special functions and classify and explain the functions of different types of differential equations.

CO5. Apply knowledge of optimization to formulate and solve engineering problems. Understand the different methods of optimization and be able to suggest a technique for a specific problem. Understand how optimization can be used to solve industrial problems of relevance to the chemical and oil industries.

Recommended Books:

1. *R. K. Jain & S. R. K. Iyenger: Advanced Engineering Mathematics, 4th Edition, Narosa publication, 2014.*
2. *M.K. Jain, S.R.K. Iyenger & R.K. Jain: Numerical Methods for Scientific & Engg. Computation, New age International Publishers, (Reprint) 2007.*
3. *S. C. Gupta & V. K. Kapoor: Fundamentals of Statistics: 11th Edition, Sultan Chand & Sons, (Reprint) 2014.*
4. *E. Kreyszig: Advanced Engineering Mathematics, 10th Edition, Wiley publication, , 2011.*
5. *B.S. Grewal: Higher Engineering Mathematics, 42nd Edition, Khanna Publication, India, 2012.*

Pre-Ph.D. (Mathematics)

DSE (Department Specific Electives)

Subject Code	MA749	**Subject Title**	MATHEMATICAL MODELING & SIMULATION						
L T P	3 1 0	**Credit**	4	**Subject Category**	DSE I	**Year**	1	**Semester**	I/II

Objective:
The goal of the course are as under:
1. Introduce students to the elements of the mathematical modeling process.
2. To understand the basic rules of logic, including the role of axioms or assumptions and appreciate the role of mathematical proof in formal deductive reasoning.
3. To develop ability to distinguish a coherent argument from a fallacious one, both in mathematical reasoning and in everyday life.
4. To make them understand and be able to articulate the differences between inductive and deductive reasoning
5. Students may proficiently construct logical arguments and rigorous proofs and formulate conjectures by abstracting general principles from examples.

Unit I
Introduction
Models, reality, Properties of models, model classification and characterization, steps in building mathematical models, sources of errors, dimensional analysis.
Modeling using Proportionality, Modeling using Geometric similarity; graphs of a functions as models.
Model Fitting – Fitting models to data graphically, Analytic methods of model fitting, Applying the least square criterion,
Experimental Modeling – High order polynomial models, Cubic Spline models.

Unit II
Discrete Probabilistic Modeling –Probabilistic modeling with discrete system; Modeling components & System Reliability; Linear Regression.
Discrete Optimization Modeling – Linear Programming – Geometric solutions, Algebraic Solutions, Simplex Method and Sensitivity Analysis.

Unit III
Modeling with a Differential Equations – Population Growth, Graphical solutions of autonomous differential equations, numerical approximation methods-- Euler's Method and R.K. Method.
Modeling with systems of Differential Equations – Predator Prey Model, Epidemic models, Euler's method for systems of Differential equations.

Unit IV
Simulation Modeling – Discrete-Evvnt Simulation, Generating random numbers; Simulating probabilistic behavior; Simulation of Inventory model and Queueing Models using C program.
Other Types of simulation—Continuous Simulation, Monte-Carlo simulation. Advantages, disadvantages and pitfalls of simulation

Case Study: Case Studies for various aspects of modeling to be done.

Course Outcomes (CO):

CO1. Translate everyday situations into mathematical statements (models) which can be solved/analyzed, validated, and interpreted in context.

CO2. Identify assumptions which are consistent with the context of the problem and which in turn shape and define the mathematical characterization of the problem.
CO3. Revise and improve mathematical models so that they will better correspond to empirical information and/or will support more realistic assumptions.
CO4. Assess the validity and accuracy of their approach relative to the problem requirement.
CO5. Apply tools to mathematically analyze and solve contemporary problems of both theoretical and practical importance and recognize the power of mathematical modelling and analysis and be able to apply their understanding to their further studies.

Recommended Books:

1. *Frank R. Giordano, Mawrice D Weir & William P. Fox: A first course in Mathematical Modeling, 3rd Edition, Thomson Brooks/Cole, Vikas Publishing House (P) Ltd., 2003.*
2. *J.D. Murray: Mathematical Biology – I, 3rd Edition, Springer International Edition, 2004.*
3. *J.N. Kapoor: Mathematical Models in Biology and Medicine, East West Press, New Delhi, 1985.*
4. *Robert E. Shannon:: Systems Simulation: The Art and Science, Prentice Hall, U.S.A, 1975.*
5. *Averill M. Law & W. David Kelton: Simulation Modeling and Analysis, 3rd Edition, Tata McGraw Hill, 1999.*

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Subject Code	MA747	**Subject Title**	FUZZY SETS AND APPLICATIONS						
L T P	3 1 0	**Credit**	4	**Subject Category**	DSE I	**Year**	1	**Semester**	I/II

Course Objectives: The aim of this course is to provide students with an understanding of:
1. The fundamental theory of fuzzy systems.
2. The need of fuzzy sets.
3. Arithmetic operations on fuzzy sets, fuzzy relations.
4. Possibility theory, fuzzy logic, and its applications.
5. Apply fuzzy systems to model and solve complicated practical problems such as recognition.

Unit I

Classical and Fuzzy Sets: Overview of classical sets, Membership function, A-cuts, Properties of a-cuts, Extension principle.

Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of operations, Aggregation operations.

Unit II

Fuzzy Arithmetic: Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals and numbers, Fuzzy equations.

Fuzzy Relations: Crisp and fuzzy relations, Projections and cylindric extensions, Binary fuzzy relations, Binary relations on single set, Equivalence, Compatibility and ordering Relations, Morphisms, Fuzzy relation equations.

Unit III

Possibility Theory: Fuzzy measures, Evidence and possibility theory, Possibility versus probability theory.

Fuzzy Logic: Classical logic, multivalued logics, Fuzzy propositions, Fuzzy qualifiers, Linguistic hedges.

Unit IV

Applications of Fuzzy Logic: Washing machines, Control systems engineering, Power engineering and Optimization.

Course Outcomes:

Upon completion of this course, the student will be able to:

CO1. construct the appropriate fuzzy numbers corresponding to uncertain and imprecise collected data.

CO2. handle the problems having uncertain and imprecise data.

CO3. find the optimal solution of mathematical programming problems having uncertain and imprecise data.

CO4. Deal with the fuzzy logic problems in real world problems.

CO5. Implement fuzzy systems to solve practical problems.

Recommended Books:

1. *G. J. Klir and Folger T.A.: Fuzzy Sets, Uncertainty and Information, 1st Edition edition, Prentice Hall Inc.,1988.*
2. *G.J. Klir and Yuan B.: Fuzzy Sets and Fuzzy logic: Theory and Applications, PHI, 1997.*
3. *H.J. Zimmermann: Fuzzy Set Theory and its Applications, 4th Edition, Allied Publishers, 2001.*
4. *J. Yen and R. Langari, Fuzzy Logic: Intelligence, Control, and Information, Pearson Education, 2003.*

Pre-Ph.D. (Mathematics)

Subject Code	MA757	**Subject Title**	NUMERICAL SOLUTION OF PDEs						
L T P	3 1 0	**Credit**	4	**Subject Category**	DSE I	**Year**	1	**Semester**	I/II

Objective: The objective of the course to teach the students:
1. the principles for designing numerical schemes for PDEs, in particular, finite difference schemes.
2. explicit & implicit schemes in 1D & 2D problems.
3. solutions linear Partial Differential with different methods.
4. the solutions of PDEs determined by conditions at the boundary of the spatial domain and initial conditions at time zero.
5. technique of separation of variables to solve PDEs and analyze the behavior of solutions in terms of eigen function expansions.

Unit-I
Numerical solutions of parabolic PDE in one space: two and three levels explicit and implicit difference schemes. Convergence and stability analysis.

Unit-II
Numerical solution of parabolic PDE of second order in two space dimension: implicit methods, alternating direction implicit (ADI) methods. Nonlinear initial BVP. Difference schemes for parabolic PDE in spherical and cylindrical coordinate systems in one dimension.

Unit-III
Numerical solution of hyperbolic PDE in one and two space dimension: explicit and implicit schemes. ADI methods. Difference schemes for first order equations.

Unit-IV
Numerical solutions of elliptic equations, approximations of Laplace and biharmonic operators. Solutions of Dirichlet, Neuman and mixed type problems.
Finite element method: Linear, triangular elements and rectangular elements.

Practical's: Based on the above contents.

Course Outcomes (CO): After the successful completion of the course, the student will be able to:
CO1. analyze the consistency, stability and convergence of a numerical scheme.
CO2. apply specific methodologies, techniques and resources to conduct research and produce innovative results in the area of specialization.
CO3. identify what kind of numerical methods are best suited for each type of PDEs (hyperbolic, parabolic and elliptic).
CO4. make a connection between the mathematical equations or properties and the corresponding physical meanings.
CO5. use a programming language (C, C++, Python etc.) or math software (Matlab, Maple or Mathematica) to implement and test the numerical schemes. (∗ Depending on the availability of time and software)

Recommended Books:

1. *M. K. Jain, S. R. K. Iyenger and R. K. Jain: Computational Methods for Partial Differential Equations, Wiley Eastern, 1994.*
2. *M. K. Jain: Numerical Solution of Differential Equations, 2nd edition, Wiley Eastern.*
3. *S. S. Sastry: Introductory Methods of Numerical Analysis, 3rd Edition, Prentice-Hall of India, 2002.*
4. *D. V. Griffiths and I. M. Smith:Numerical Methods for Engineers, 2nd Edition, Oxford University Press, 2006.*
5. *C. F. Gerald and P. O. Wheatley: Applied Numerical Analysis, 7th Edition, Pearson Addison-Wesley, 2004.*

Pre-Ph.D. (Mathematics)

Subject Code	MA759	Subject Title	DYNAMICAL SYSTEMS						
L T P	3 1 0	Credit	4	Subject Category	DSE I	Year	1	Semester	I/II

Course Objectives: The objective of the course to teach the students:
1. introduction to the fundamental notions of the qualitative theory of differential equations.
2. introduction to the fundamental notions of dynamical systems.
3. background for advanced studies potentially leading to research activities in this field.
4. relevant interdisciplinary fields for which the study of emerged dynamical systems.

Unit I

Equilibrium Solutions, Stability, and Linearized Stability for vector fields and maps, Lyapunov Functions, Invariant Manifolds: Linear and Nonlinear Systems for vector fields and maps, Periodic orbits

Unit II

Some General Properties of Vector Fields: Existence, Uniqueness, Differentiability, and Flows, Asymptotic Behavior, Poincare Maps.

Unit III

Center Manifolds for Vector Fields, Center Manifolds Depending on Parameters, Center Manifolds for Maps, Properties of Center Manifolds, Normal form for vector fields, Normal form for vector fields with parameters, Normal forms for maps.

Unit IV

Bifurcation of Fixed Points of Vector Fields, The Saddle-Node Bifurcation, The Transcritical Bifurcation, The Pitchfork Bifurcation, Codimension of a Bifurcation

Unit V

Bifurcations of Fixed Points of Maps, The Saddle-Node Bifurcation, The Transcritical Bifurcation, The Pitchfork Bifurcation, Period Doubling, Codimension of Bifurcations of Maps.

Course Outcomes: After completing this course, students should demonstrate competency in the following skills:

CO1. To understand the dynamics, and the structure of the phase-plane of linear systems.

CO2. To apply local techniques, for the analysis of the local phase portrait of non-linear systems.

CO3. To apply Lyapunov and invariant manifold methodologies, in order to analyze the stability properties of nonlinear systems.

CO4. To understand and recognize fundamental nonlinear phenomena such as the emergence of limit cycles, and bifurcations.

CO5. To understand and apply global non-linear techniques, based on Poincaré-Bendixson theorem.

Recommended Books:

1. *Stephen Wiggins: Introduction to Applied Nonlinear Dynamical Systems and Chaos, 2nd Edition, Springer, New York.*
2. *D. K Arrowsmith, C. M Place: An Introduction to dynamical system, 1st Edition, Cambridge University Press, 1990.*
3. *Yuri Kuznetsov: Elements of applied bifurcation theory, 3rd Edition, Springer-Verlag New York*, 2004.

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Subject Code	MA758	**Subject Title**	INTEGRAL EQUATIONS & CALCULUS OF VARIATIONS						
L T P	3 1 0	**Credit**	4	**Subject Category**	DSE II	**Year**	1	**Semester**	I/II

Course Objective: The main goal of this course is to introduce to students:
1. fundamental concepts and some standard results of the integral equations.
2. the methods of solving Integral Equations.
3. the problems of the calculus of variations and its many methods and techniques without using deep knowledge of functional analysis.
4. conversion of integral equations to differential equations.
5. numerical Methods for solving Integral equations.

Unit I

Inner Product spaces, Norm, Hilbert space, Regularity Conditions, Special kinds of Kernel, Classification of integral equation, Convolution integral, Relation between differential and integral equations, Classification, Conversion of Volterra Equation to ODE, Conversion of IVP and BVP to Integral Equation.

Unit II

Fredholm integral equations, Solution of Fredhlom integral equation using decomposition method, direct computation, Adomain decomposition, successive approximation and successive substitution methods.
Volterra Integral equations, Solution of Volterra integral equation using successive approximation method, Adomian decomposition method, series solution, successive substitution method, resolvent kernel, Volterra integral equation of first kind, Integral equations with seperable kernels.

Unit III

Fredholm's first, second and third theorem, Integral Equations with symmetric kernel, Eigen function expansion, Hilbert-Schmidt theorem, Fredholm and Volterra Integro-Differential equation, Operator method in the theory of integral equations, Rayleigh-Ritz method for finding eigenvalue, Singular Integral Equation. Numerical Methods for solving Integral equations (Collocation method, least square method).

Unit IV

Introduction, problem of Brachistochrone, Isoperimetric problem, Variation and its properties, functions and functionals, Variational problems with the fixed boundaries, Euler's equation, Functionals in the form of integrals, special cases containing only some of the variables, Functionals involving more than one dependent variables and their first derivatives, the system of Euler's equations, Functionals depending on the higher derivatives of the dependent variables, Functionals containing several independent variables, Variational problems in parametric form.

Unit V

Variational problems with moving boundaries, one sided variations, variational problems with subsidiary conditions, Isoperimetric problems, Numerical methods for solving varitional problems, Rayleigh – Ritz method, Galerkin’s Method.

Course Outcomes (CO): At the end of the course, student will be able:

CO1. to recognize difference between Volterra and Fredholm Integral Equations, First kind and Second kind, homogeneous and inhomogeneous etc.

CO2. to apply different methods to solve Integral Equations and fully understand the properties of geometrical problems.

CO3. to understand the fundamental concepts of the space of admissible variations.

CO4. to understand weak and a strong relative minimum of an integral..

CO5. to exposed to the decomposition method.

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Recommended Books:

1. *Ram P. Kanwal: Linear Integral Equations Theory and Technique, 2nd Edition, Birkhauser, 2013..*
2. *I. M. Gelfand, S. V. Fomin: Calculus of variations, 3rd Edition, Prentice-Hall, 1963.*

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Subject Code	MA766	Subject Title	MAGNETOHYDRODYNAMICS						
L T P	3 1 0	Credit	4	Subject Category	DSE II	Year	1	Semester	I/II

Course Objectives: The main goal of this course is to introduce to students:
1. the fundamental concepts of magnetohydrodynamics.
2. theory of Maxwell's equations and basic equations.
3. Exact solution of classical MHD.
4. two dimensional MHD Flows.
5. applications of MHD.

Unit I
Basic concepts of Magneto-hydrodynamics and its applications, Maxwell's equations, Frame of reference, Lorentz force, Electromagnetic body force.

Unit II
Fundamental equations of MHD, Ohm's law for a moving conductor, Hall current, Conduction current, Kinematic aspect of MHD, Magnetic Reynolds number, MHD waves: Alfven's waves, MHD waves in compressible fluid, MHD approximations.

Unit III
Electromagnetic boundary conditions, One dimensional MHD flow, Hartmann flow, MHD Couette flow, MHD Stoke's flow, MHD Rayleigh's flow, Hartmann-Stoke's boundary layer, Alfven's boundary layer.

Unit IV
Two dimensional MHD flow (a) Aligned flow (b) Stagnation point flow, MHD flows in a rotating medium, Effects of Hall current on MHD flows in a rotating channel, MHD heat transfer.

Course Outcomes: Upon successful completion of this course, students will be able to

CO1: to provide the details of the derivation of ideal and resistive MHD equations.

CO2. to demonstrate the basic properties of ideal MHD.

CO3. to solve problems under different kind of flows.

CO4. to apply kinematic aspect of MHD in compressible fluid.

CO5. theoretical and practical background to Ph. D. thesis in heat transport.

Recommended Books:

1. T. G. Cowling: Magnetohydrodynamics, Interscience Publishers New York, 1957.
2. J.A. Shercliff: A Text Book of Magnetohydrodynamics,1st Edition, Pergamon Press, Oxford, 1965.
3. S.I. Pai: Magnetohydrodynamics and Plasma Dynamics, 1st Edition, Springer Verlag, New York, (2nd Reprint)1963.
4. K. R. Cramer and S. I. Pai: Magnetofluid Dynamics for Engineers and Applied Physicists, McGraw Hill, New York, 1973.

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Subject Code	MA767	Subject Title	THERMAL INSTABILITIES AND METHODS						
L T P	3 1 0	**Credit**	4	**Subject Category**	DSE II	**Year**	1	**Semester**	I/II

Course Objectives: The main goal of this course is to introduce to the students:

1. the fundamental of thermal stabilities, heat and mass transfer in incompressible fluids.
2. convection under rotation, magnetic field and solute gradients.
3. different kinds of convection instabilities.
4. linear and non-linear stability problems.
5. different kind of numerical techniques to solve convection problems.

Unit I

Fundamentals of hydrodynamic stability, Rayleigh-Benard convection, concepts of porous medium, Darcy's law, Brinkman equation, equations for conservation of mass, momentum and energy in fluid and porous medium, Boussinesq approximations, boundary conditions, normal modes, cell patterns.

Unit II

Heat and mass transfer in fluid and porous medium, Convection under rotation. Magnetic field and solute gradient. Nonlinear stability. Introduction to Nano fluids, Ferro fluids and polar fluids.

Unit III

Mechanism of instability, various types of convection instabilities; Rayleigh-Benard convection, Oberbeck convection, magneto-convection, Marangoni convection, magneto-Marangoni convection, magnetic fluid convection, electro convection, double diffusive convection, cross diffusion convection, biconvection.

Unit IV

Boundary conditions. Techniques to solve linear and nonlinear instability problems; Galerkin technique, perturbation techniques involving regular and singular perturbations.

Unit V

Truncated representation of Fourier series (finite amplitude technique), numerical techniques, moment method, energy method, power integral technique, Spectral method.

Course Outcomes: Upon successful completion of this course, students will be able to

CO1. solve equations for conservation of mass, momentum and energy in fluid with porous medium under defined constraints.

CO2. apply convection concepts in heat and mass transfer problems with different kind of fluids.

CO3. apply numerical techniques to solve linear and non-linear instability problems.

CO4. understand various types of convection instabilities like Rayleigh-Benard convection, Oberbeck convection, magneto-Marangoni convection, magnetic fluid convection, electro convection etc.

CO5. understand perturbation techniques like regular and singular perturbations.

Recommended Books:

1. *D.A. Nield, A. Bejan: Convection in Porous Medium, 5th Edition, Springer International Publishing, 2017.*
2. *S.K. Som & G. Biswas: Introduction to Fluid Mechanics and Fluid Machines, Reviesd 2nd Edition, Tata McGraw-Hill, 2010.*
3. *P.G. Drazin, W.H. Reid: Hydrodynamic Stability, 2nd Edition, Cambridge University Press, 2004.*
4. *S. Chandrasekhar: Hydrodynamic and Hydromagnetic Stability, Dover Publications, Dover Edition, 2013.*

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Subject Code	MA768	Subject Title	STATISTICAL TECHNIQUES						
L T P	3 1 0	**Credit**	4	**Subject Category**	DSE II	**Year**	1	**Semester**	I/II

Course Objectives: The main goal of this course is to introduce to the students:

1. the concepts of random variable and stochastic processes.
2. sampling techniques and parameter estimation.
3. point and interval estimation of parameters.
4. types of hypothesis and hypothesis testing.
5. basics of decision theory.

Unit I: Stochastic Processes

Markovian property, continuous time Markov Chains, Poisson Process, Birth and Death Process, Application in Insurance and Finance. Brownian Motion: Basic concepts of Stochastic Differential equations, Ito integrals, Geometric Brownian motion.

Unit II: Sampling

Simple random sampling, Stratified random sampling, PPS –sampling, Lahiri's scheme and Des Raj estimator, Murthy estimator (for n=2). Horvitz Thompson Estimator of finite population total/mean, Expression for Variance (HTE) and its unbiased estimator.

Unit III: Inference

Point estimation, interval estimation, hypothesis testing, two type of errors, power function, shortest confidence interval, Cramer-Rao inequality, minimal sufficiency, Rao-Blackwell theorem.

Unit IV: Decision Theory

Basic elements of Statistical Decision Problem. Expected loss, decision rules (nonrandomized and randomized), decision principles, inference as decision problem, optimal decision rules. Bayes and minimax decision rule. Admissibility of minimax rules and Bayes rules.

Course Outcomes: Upon successful completion of this course, students will be able to

CO1. understand the concept of stochastic process with their types and properties.

CO2. understand sampling techniques.

CO3. understand estimation theory.

CO4. understand the concepts of hypothesis testing and two types of errors.

CO5. understand the tool used in decision theory.

Recommended Books:

1. *Sheldon M. Ross: S. Stochastic Processes, 2nd Edition, John Wiley and Sons, New York, 1996.*
2. *E.L. Lehmann. and Romano J.P: Testing Statistical Hypotheses, 3rd Edition, Springer-Verlag New York, 2005.*
3. *E.L. Lehmann and George Casella: Theory of Point Estimation, 2nd Edition, Springer Inc., 1998.*

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Subject Code	CS753	Subject Title	DISTRIBUTED SYSTEM						
L T P	4 0 0	**Credit**	4	**Subject Category**	DSE II	**Year**	1	**Semester**	I

Objective: The main goal of course is to learn the principles, architectures, algorithms and programming models used in distributed systems.

Unit I
Fundamentals of Distributed Computing: Architectural models for distributed computing systems, Issues and challenges in Distributed systems, Basic concepts in distributed computing such as clocks, message ordering, consistent global states.
Distributed Environments, Current systems and developments (DCE, CORBA, JAVA).

Unit II
Coordination & Synchronization: Introduction, Distributed Mutual Exclusion, Elections, Multicast Communication, Atomic transactions, Deadlocks in Distributed systems.
Message Passing & Remote Procedure Calls: Features of a good message-passing system, RPC model. Implementing RPC mechanism, Stub Generation, RPC Messages, Marshaling Arguments and Results, Server Management, Communication protocols for RPCs.

Unit III
Distributed File Systems: Features of Good DFS, File Models, File-Accessing models, File Service Architecture, File-sharing semantics, File Caching schemes, File replications.

Unit IV
Distributed Shared Memory: Shared memory consistency models, Page based distributed shared memory, Shared variable distributed shared memory, Object based distributed shared memory.
Replication: Introduction, System Model & Group Communication, Fault Tolerant Services, Transactions with Replicated Data.

Unit V
Advanced Topics in Distributed Computing: High Performance Computing-HPF, Distributed and mobile multimedia systems. Adaptability in Mobile Computing. Grid Computing and applications. Fault tolerant Computing Systems.

Course Outcome (CO):
The primary learning outcome of the course is two-fold:
CO1. Students will identify the core concepts of distributed systems: the way in which several machines orchestrate to correctly solve problems in an efficient, reliable and scalable way.
CO2. Students will examine how existing systems have applied the concepts of distributed systems in designing large systems, and will additionally apply these concepts to develop sample systems.

Recommended Books:

1. Tannenbaum, A, Van Steen ,Distributed Systems, Principles and Paradigm, Prentice Hall India, 2002.
2. Tannenbaum, Distributed Operating Systems, A. Pearson Education, 2006.
3. Attiya, Welch, Distributed Computing, Wiley India, 2006.
4. Singhal and Shivaratri, "Advanced Concepts in Operating Systems", McGraw Hill, 1994