DIT UNIVERSITY
Dehradun

Detailed Course Structure & Syllabus
of
Ph.D. in Mathematics

Approved by the Academic Council at its 17th Meeting held on 24.03.2021

Course Structure & Syllabus of Ph.D. Mathematics
Applicable for Batch: 2021 Onwards

Year 1 **Semester 1 /II**

Category	Course Code	Course Name	L	T	P	Credit
CC	MB901	Research Methodology	3	1	0	4
CC	CPE-RPE	Research Publication and Ethics	3	1	0	2
CC	MA601	Advanced Mathematics	3	1	0	4
DSE		DSE-1				4
DSE		DSE-2				4
SEC	MA629	Seminar				1
Total						**19**

DSE-1

Category	Course Code	Course Name	L	T	P	Credit
DSE	MA647	Fuzzy Sets and Applications	3	1	0	4
DSE	MA746	Mathematical Modelling and Simulations	3	1	0	4
DSE	MA758	Numerical Solution of PDE's	3	0	2	4
DSE	MA649	Integral Equations & Calculus of Variations	3	1	0	4

DSE-2

Category	Course Code	Course Name	L	T	P	Credit
DSE	MA749	Dynamical Systems	3	1	0	4
DSE	MA766	Magneto hydrodynamics	3	1	0	4
DSE	MA767	Thermal Instabilities and Methods	3	1	0	4
DSE	MA768	Statistical Techniques	3	1	0	4

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.

Course Structure & Syllabus of Ph.D. Mathematics
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Course Title	Research Methodology
Course Code	MB901
Credits	4
Course Category	CC
Year	I
L T P	3 1 0
Course Objectives	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.
Course Outcomes	After studying this course the student will be able to **CO1**: understand the fundamentals of research. **CO2:** describe how to design the exploratory and experimental research problems. **CO3:** work with sampling problems and distributions with the same. **CO4:** calculate different aspects of data's with SPSS software. **CO5:** write a good research proposal and reports.

Syllabus	**No. of Lectures**
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	10
Unit-II: Research Design Design of Experiments: Research Designs -Exploratory, Descriptive and Experimental, Experimental designs- Types of Experimental Designs	8
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.	8
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	8
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.	8
Total No. of Lectures	**42**

Text 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
References Books	1. 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. 2. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997. 3. Bordens K.S. and Abbott, B.b.: Research Design and Methods, Mc Graw Hill, 2008. 4. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197 -222; 391 – 403.

Course Title	Research and Publication Ethics
Course Code	CPE-RPE
Credits	2
Course Category	CC
Year	I
L T P	2 0 0
Course Objectives	**Course Objective:** There are three objectives in research ethics. 1. The first objective is to protect human participants. 2. The second objective is to ensure that research is conducted in a way that serves interests of individuals or society as a whole. 3. And the third objective is to examine specific research activities and projects for their ethical soundness, looking at issues such as the management of risk, protection of confidentiality and the process of informed consent. An ethically correct research involving human participants must include the following components.

Syllabus	No. of Lectures
UNIT-I: Philosophy & Ethics **Introduction to Philosophy**– Definition, nature & scope, concept, branches **Ethics**- Definition, moral Philosophy, nature of moral judgment and reactions	4
UNIT-II: Scientific Conduct ● Ethics with respect to science & research, ● Intellectual honesty and research integrity, ● Scientific Misconduct: Falsification, Fabrication and Plagiarism (FFP), ● Redundant Publications: duplicate & overlapping applications, ● Salami slicing, selective reporting & misrepresentation of data	4
UNIT-III: Publication Ethics Publication Ethics: Definition, introduction & importance ● Best practices/standards settings initiatives & guidelines: COPE, WAME etc. ● Conflicts of interest ● Publication Misconduct: definition, concept, problems that lead to unethical behavior and vice versa type ● Violation of public ethics, authorship and contributor ship ● Identification of publication misconduct, complaints & appeals ● Predatory publishers & journals **Practice**:	4
UNIT-IV: Open Access Publishing ● Open Access publication & initiatives. ● SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies ● Software tool to identify predatory publications developed by SPPU ● Journal finder/journal suggestion tools viz, JANE, Elsevier Journal Finder, Springer Journal Suggested etc.	4
UNIT-V: Publication Misconduct **A. Group Discussion** ● Subject specific ethical issues, FFP, authorship ● Conflicts of interest ● Complaints & appeals: examples & fraud from India & Abroad. **B. Software tools** ● Use of plagiarism software like Turnitin, Urkund and other open source software tools.	4
UNIT-VI: Databases & Research Metrics **A. Databases** ● Indexing databases ● Citation databases: Web of science, Scopus etc. **B. Research Metrics** ● Impact factor of journal as per journal citation report, SNIP, SJR, IIP, Cite Score ● Metrics: h- Index, g index, i10 index, altmetrics.	4

Course Structure & Syllabus of Ph.D. Mathematics
Applicable for Batch: 2021 Onwards

Course Title	Advanced Mathematics
Course Code	MA601
Credits	4
Course Category	CC
Year	I
L T P	3 1 0
Course Objectives	To teach the student various topics in Numerical Analysis, linear Partial Differential with different methods. To derive heat and wave equations in 2D and 3D, statistical concepts to include measurements of location and dispersion, probability, probability distributions, sampling, estimation, hypothesis testing, Legendre Polynomial which may be solved by application of special functions, and optimization methods and algorithms developed for solving various types of optimization problems.
Course Outcomes	After studying this course the student will be able to **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. **CO2**. Solve linear partial differential equations of both first and second order. Apply partial derivative equation techniques to predict the behavior of certain phenomena. **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. **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.

Syllabus	**No. of Lectures**
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.	10
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.	8
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.	8
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.	8
Unit V: Optimization Formulation, Graphical method, Simplex method, Two-Phase simplex method, Duality, Primal-dual relationship, Dual-simplex method.	8
Total No. of Lectures	**42**

Text Books	1. R. K. Jain & S. R. K. Iyenger: *Advanced Engineering Mathematics*, 4th Edition, Narosa publication, 2014.
References Books	1. M.K. Jain, S.R.K. Iyenger & R.K. Jain: *Numerical Methods for Scientific & Engg. Computation*, New age International Publishers, (Reprint) 2007. 2. S. C. Gupta & V. K. Kapoor: *Fundamentals of Statistics*: 11th Edition, Sultan Chand & Sons, (Reprint) 2014.

Course Title	Fuzzy Sets and Applications
Course Code	MA647
Credits	4
Course Category	DSE
Year	I
Prerequisite Courses	Preliminary knowledge of Set Theory
L T P	3 1 0
Course Objectives	The objective of this course is to teach the students the need of fuzzy sets, arithmetic operations on fuzzy sets, fuzzy relations, possibility theory, fuzzy logic, and its applications.
Course Outcomes	After studying 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:** know the concepts of fuzzy graph, fuzzy relation, fuzzy morphism and fuzzy numbers. **CO5:** deal with the fuzzy logic problems in real world problems.

Syllabus	**No. of Lectures**
Unit-I: Fuzzy Sets Overview of classical sets, Membership function, A-cuts, Properties of a-cuts, Extension principle. Compliment, Intersections, Unions, Combinations of operations, Aggregation operations.	8
Unit-II: Fuzzy Arithmetic Fuzzy numbers, Linguistic variables, Arithmetic operations on intervals and numbers, Fuzzy equations.	8
Unit-III: 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.	10
Unit IV: Possibility Theory & Fuzzy Logic Fuzzy measures, Evidence and possibility theory, Possibility versus probability theory. Classical logic, Multivalued logics, Fuzzy propositions, Fuzzy qualifiers, Linguistic hedges.	8
Unit-V: Applications of Fuzzy Logic Washing machines, Control systems engineering, Power engineering and Optimization.	8
Total No. of Lectures	**42**

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

Course Structure & Syllabus of Ph.D. Mathematics Applicable for Batch: 2021 Onwards

Course Title	Mathematical Modelling and Simulations
Course Code	MA746
Credits	4
Course Category	DSE
Year	I
Prerequisite Courses	Differential equation and optimization theory.
L T P	3 1 0
Course Objectives	The goal of the course is to introduce students to the elements of the mathematical modeling process, the basic rules of logic, including the role of axioms or assumptions, logical arguments, and rigorous proofs and formulation of conjectures by abstracting general principles from examples.
Course Outcomes	After studying this course the student will be able to **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 the approach relative to the problem requirement. **CO5:** apply tools to mathematically analyze and solve contemporary problems.

Syllabus	**No. of Lectures**
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.	8
Unit II: Modeling Modeling using Proportionality, Modeling using Geometric similarity; graphs of a functions as models. Fitting models to data graphically, Analytic methods of model fitting, Applying the least square criterion, High order polynomial models, Cubic Spline models.	8
Unit III: Discrete Probabilistic & Optimization Modeling Probabilistic modeling with discrete system; Modeling components & System Reliability; Linear Regression. Linear Programming – Geometric solutions, Algebraic Solutions, Simplex Method and Sensitivity Analysis.	8
Unit IV: Modeling with a Differential Equations Population Growth, Graphical solutions of autonomous differential equations, numerical approximation methods-- Euler's Method and R.K. Method. Predator Prey Model, Epidemic models, Euler's method for systems of Differential equations.	8
Unit V : Simulation Modeling Discrete-Evnt Simulation, Generating random numbers; simulating probabilistic behavior; Simulation of Inventory model and Queuing Models using C program. Other Types of simulation—Continuous Simulation, Monte-Carlo simulation. Advantages, disadvantages and pitfalls of simulation	10
Total No. of Lectures	**42**

Text 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. Murray J.D., *Mathematical Biology – I*, 3rd Edition, Springer International Edition, 2004. 3. Kapoor J.N., *Mathematical Models in Biology and Medicine*, East West Press, New Delhi, 1985.
References Books	1. Robert E. Shannon, *Systems Simulation: The Art and Science*, Prentice Hall, U.S.A, 1975. 2. Law Averill M. & Kelton W. David, *Simulation Modeling and Analysis*, 3rd Edition, Tata McGraw Hill, 1999.

Course Structure & Syllabus of Ph.D. Mathematics
Applicable for Batch: 2021 Onwards

Course Title	Numerical Solutions of PDEs
Course Code	MA758
Credits	4
Course Category	DSE
Year	I
Prerequisite Courses	
L T P	3 0 2
Course Objectives	Introduce the finite difference schemes (FDS), order of accuracy of a scheme, concept of stability convergence, dissipation and dispersion, and exposed to FDS for hyperbolic, parabolic and elliptic PDE's.
Course Outcomes	After studying this course the student will be able to **CO1**: apply FDS to solve partial differential equations. **CO2:** describe the boundary conditions for different schemes. **CO3:** understand the convergence estimate for parabolic equation, well-posed, and stable stable initial BVP. **CO4:** solve parabolic and elliptic PDEs with ADI schemes and FDS respectively. **CO5:** apply finite difference schemes to solve Poisson's equation.

Syllabus	**No. of Lectures**
Unit-I: Linear stability and convergence Introduction to hyperbolic PDE's, finite difference schemes, convergence and consistency, CFL number and Fourier and Von Neumann stability analysis for FDS.	8
Unit-II: Dissipation and dispersion Order of accuracy of LxW and Crank-Nicolson finite difference schemes boundary condition, Thomas algorithm, dissipation and dispersion.	8
Unit-III: Parabolic PDE's Parabolic systems and boundary conditions, finite difference schemes for parabolic and convection diffusion equations, ADI scheme on square, boundary conditions and stability for ADI schemes.	8
Unit-IV: Well-posed systems and estimations The theory of well-posed IVP**s** scalar and systems, convergence estimates for smooth and non-smooth initial conditions, convergence estimate for parabolic differential equations, Lax-Richmyer equivalence theorem, well-posed and stable initial BVP, matrix method for stability.	10
Unit-V: Elliptic PDE's Elliptic equations and regularity estimates, maximum principle and boundary condition, finite difference schemes for Poisson's equation.	8
Total No. of Lectures	**42**

Text Books	1. Thomas J. W., *Numerical Partial Differential Equations: Finite Difference Methods*, Springer, 1998. 2. Strikwerda J. C., *Finite Difference Schemes and Partial Differential Equations*, SIAM, Philadelphia, 2nd Ed., 2004.
References Books	1. Leveque R. J., *Finite Difference Methods for Ordinary and Partial Differential Equations, Steady State and Time Dependent Problems*, SIAM Philadelphia, 2007. 2. Smith G. D., *Numerical Solution of Partial Differential Equations: Finite Difference Methods*, Oxford University press, 1977.

Course Title	Integral Equation and Calculus of Variations
Course Code	MA649
Credits	4
Course Category	DSE
Year	I
Prerequisite Courses	
L T P	3 1 0
Course Objectives	The main goal of this course is to introduce to students the fundamental concepts and some standard results of the integral equations, the methods of solving Integral Equations, the problems of the calculus of variations and its many methods and techniques without using deep knowledge of functional analysis.
Course Outcomes	After studying this course the student will be able to **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 variational problems with moving boundaries.

Syllabus	**No. of Lectures**
Unit-I: **Preliminary Concepts** Definition and classification of linear integral equations. Conversion of initial and boundary value problems into integral equations. Conversion of integral equations into differential equations. Integro-differential equations.	8
Unit-II: Fredholm Integral Equations Solution of integral equations with separable kernels, Eigenvalues and Eigen functions. Solution by the successive approximations, and resolvent kernel. Solution of integral equations with symmetric kernels, Hilbert-Schmidt theorem, Green's function approach.	8
Unit-III: Fredholm Classical Theory Fredholm method of solution and Fredholm theorems.	8
Unit-IV: Volterra Integral Equations Successive approximations, Neumann series and resolvent kernel. Equations with convolution type kernels. Singular integral equations, Hilbert-transform, Cauchy type integral equations.	8
Unit-V: Calculus of Variations Basic concepts of the calculus of variations such as functionals, extremum, variations, function spaces, the brachistochrone problem. Necessary condition for an extremum, Euler's equation with the cases of one variable and several variables, Variational derivative. Invariance of Euler's equations. Variational problem in parametric form. Functionals dependent on one or two functions, Derivation of basic formula, Variational problems with moving boundaries, Broken extremals: Weierstrass –Erdmann conditions.	10
Total No. of Lectures	**42**

Text Books	1. Jerry, A. J., *Introduction to Integral Equations with Applications*, Wiley Publishers (2nd Edition), 1999. 2. Kanwal R. P., *Linear Integral Equations*, Birkhäuser Bosten, (2nd Edition), 1997. 3. Weinstock R., *Calculus of Variations with Applications to Physics and Engineering*, Dover Publications, 1974.
References Books	1. Chambers, L. G., *Integral Equations: A Short Course*, International Text Book Company Ltd., 1976. 2. Gelfand, I. M., Fomin, S. V., *Calculus of Variations*, Dover Books, 2000.

Course Title	Dynamical Systems
Course Code	MA749
Credits	4
Course Category	DSE
Year	I
Prerequisite Courses	Fluid Dynamics
L T P	3 1 0
Course Objectives	The goal of the course to introduce the students with the concepts of well-posedness of differential equations, to familiarize with Bifurcations in 1Dand 2D flows, chaos, and exposure to stability analysis.
Course Outcomes	After studying this course the student will be able to **CO1**: understand the Lipschitz condition, well-posedness of differential equation and contraction mapping theorem. **CO2:** describe the stability and bifurcation. **CO3:** understand nonlinear autonomous system in 2D flows. **CO4:** apply variable gradient method. **CO5:** understand the chaos and attractors.

Syllabus	**No. of Lectures**
Unit-I: Mathematical preliminaries Open and closed sets, compact set, dense set, continuity of functions, Lipschitz condition, smooth functions, vector space, normed linear space, inner product space, well-posedness of ordinary differential equations, Lipschitz continuity and contraction mapping theorem.	9
Unit-II: One-dimensional flows Fixed points and stability, linear stability analysis, saddle- node bifurcation, transcritical bifurcation, pitchfork bifurcation, flows on the circle.	9
Unit-III: Two-dimensional flows Linear systems, nonlinear autonomous systems, phase portraits, fixed points and linearization, conservative systems, index theory, limit cycles, Poincare Bendixson theorem, Bendixson's criteria, Lienard systems.	10
Unit-IV: Lyapunov stability Variable gradient method, LaSalle's invariance property, transcritical and pitchfork bifurcations, Hopf bifurcation, Poincare maps.	10
Unit-V: Chaos Introduction to chaos and attractors.	4
Total No. of Lectures	**42**

Text Books	1. Strogatz S. H., *Nonlinear Dynamics and Chaos*, Perseus books publishing, 1994. 2. Ricardo H. J., *A Modern Introduction to Differential Equations*, Academic Press, 2nd Ed., 2009. 3. Khalil H. K., *Nonlinear Systems*, PHI, 1996.
References Books	1. Wiggins S., *Introduction to Applied Nonlinear Dynamical Systems and Chaos*, Springer, 1996. 2. Meiss J. D., *Differential Dynamical Systems*, SIAM, 2007. 3. Grimshaw R., *Nonlinear Ordinary Differential Equations*, Blackwell Scientific Publications, 1990.

Course Title	**Magnetohydrodynamics**
Course Code	MA766
Credits	4
Course Category	DSE
Year	I
L T P	3 1 0
Course Objectives	The main goal of this course is to introduce to students the fundamental concepts of magnetohydrodynamics, theory of Maxwell's equations and basic equations, Exact solution of classical MHD, two dimensional MHD Flows and applications of MHD.
Course Outcomes	**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.

Syllabus	**No. of Lectures**
Unit I Basic concepts of Magneto-hydrodynamics and its applications, Maxwell's equations, Frame of reference, Lorentz force, Electromagnetic body force.	8
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.	12
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.	12
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.	10
Total No. of Lectures	**42**

Text 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.
References Books	1. S.I. Pai, *Magnetohydrodynamics and Plasma Dynamics*, 1st Edition, Springer Verlag, New York, (2nd Reprint), 1963. 2. K. R. Cramer and S. I. Pai, Magnetofluid *Dynamics for Engineers and Applied Physicists*, McGraw Hill, New York, 1973.

Course Title	Thermal Instabilities and Methods
Course Code	MA767
Credits	4
Course Category	DSE
Year	I
L T P	3 1 0
Course Objectives	The main goal of this course is to introduce to the students the fundamental of thermal stabilities, heat and mass transfer in incompressible fluids, convection under rotation, magnetic field and solute gradients, different kinds of convection instabilities, linear and non-linear stability problems, and different kind of numerical techniques to solve convection problems.
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.

Syllabus	**No. of Lectures**
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.	10
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.	8
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.	10
Unit IV Boundary conditions. Techniques to solve linear and nonlinear instability problems; Galerkin technique, perturbation techniques involving regular and singular perturbations.	6
Unit V Truncated representation of Fourier series (finite amplitude technique), numerical techniques, moment method, energy method, power integral technique, Spectral method.	8
Total No. of Lectures	**42**

Text 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.
References Books	1. P.G. Drazin, W.H. Reid, Hydrodynamic *Stability*, 2nd Edition, Cambridge University Press, 2004. 2. S. Chandrasekhar, *Hydrodynamic and Hydromagnetic Stability*, Dover Publications, Dover Edition, 2013.

Course Structure & Syllabus of Ph.D. Mathematics Applicable for Batch: 2021 Onwards

Course Title	Statistical Techniques
Course Code	MA768
Credits	4
Course Category	DSE
Year	I
L T P	3 1 0
Course Objectives	The main goal of this course is to introduce to the students the concepts of random variable and stochastic processes, sampling techniques and parameter estimation., point and interval estimation of parameters, types of hypothesis and hypothesis testing, basics of decision theory.
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.

Syllabus	No. of Lectures
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.	10
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.	10
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.	10
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.	12
Total No. of Lectures	**42**

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