

Department of Mathematics and Statistics
Faculty of Science
Gurukula Kangri Vishwavidyalaya, Haridwar

Course Work for Ph. D. Mathematics Students

Every student admitted in Mathematics Ph. D. program will be required to pass in the course work comprising five units. The division of this course work is in two categories. Group-A units (Two units) are compulsory for each Ph.D. Mathematics student. Group -B units (Any three units) are discipline specific courses.

Group - A (Compulsory units)

1. **MTPC-101 Research Methodology**
2. **MTPC-102 Quantitative Methods, Data Analysis, Computational Methods and Computer Applications**

Group - B (Three Electives)

Any three units that will be decided by the department.

1. **MTPC -151 Real and Complex Analysis**
2. **MTPC- 152 Differential Equations**
3. **MTPC-153 Numerical Methods**
4. **MTPC -154 Operations Research**
5. **MTPC-155 Integral Equations**
6. **MTPC-156 Fuzzy Sets and Applications**
7. **MTPC -157 Graph Theory**
8. **MTPC-158 Mathematical Modeling**
9. **MTPC-159 Probability and Statistics**
10. **MTPC-160 Wavelet Transforms and Their Applications**

Ph. D. Mathematics Course Structure

MTPC -101 Research Methodology

Meaning of research, Objectives of research, Motivation in research, Types of research, Research approaches, Significance of research, Research methods versus methodology, Research and scientific method, Importance of knowing how research is done, Research process, Criteria of good research.

MTPC-102 Quantitative Methods, Data Analysis, Computational Methods and Computer Applications

MATLAB: Array, script and function files, two - dimensional and three - dimensional plots, importing and exporting data Programming in MATLAB: Principles of program design using MATLAB, Programming fundamentals, debugging techniques, program organization, performance evaluation, array manipulation, and user input and output, Solutions of numerous application examples using MATLAB.

MTPC-151 Real and Complex Analysis

Real Analysis: Infinite product and its convergence, uniform convergence of infinite product, double series, double series of positive real numbers and its convergence, double series of complex numbers and Blaschke product, Gamma function and its asymptotic behavior, repeated integrals, Weierstrass approximation theorem.

Complex Analysis: Elementary properties of analytic functions and complex integration, Meromorphic functions, Poisson integral, Jensen's theorem, Carleman's theorem, Littlewood's theorem, singularities, Riemann surfaces and properties. Riemann zeta function, Riemann hypothesis, Hadamard's theorems, conformal mappings, Riemann mapping theorem, Dirichlet's series.

Suggested Reading:

1. Aliprantis CD. Principles of Real Analysis (3/e), Academic Press.
2. Knopp K. Theory and Applications of Infinite Series, Blackie and Sons.
3. Conway J.B. Functions of One Complex Variables, Springer / Narosa.
4. E. Hewitt and K. Stromberg Real and Abstract Analysis, Springer

MTPC-152 Differential Equations

Existence and uniqueness of initial value cases, Picard's theorem, Analytical solutions of non - linear differential equations by asymptotic methods: Variational approaches, Parameter expanding methods, Parameterized perturbation method, Iteration perturbation methods, Homotopy methods, Greens functions and boundary value problems. First order PDE: Method of characteristics, Wave equation, Weak solution, system of PDE.

Linear PDE: Dimensional analysis and self similarity, Regular and singular perturbation, Asymptotic and complete solutions.

Non linear PDE: Conversion of non linear PDE into linear PDE, Some exactly solvable cases, Burgers equation, Singular perturbation: Boundary layer idea, Shallow water theory.

Suggested Reading:

1. V. Laxmikantham and V. Raghavendra A Text Book of Ordinary Differential equations, TMH.
2. P. Prasad and R. Ravindram Partial Differential Equations, Wiley Eastern
3. L. Debnath Non-linear Partial Differential Equations for Scientists and Engineering, Birkhauser.

MTPC-153 Numerical Methods

Finite Difference Methods for elliptic, Parabolic and hyperbolic problems. Stability, Consistency and convergence of finite difference schemes.

Finite Element Analysis, Integral formulations and variational methods, Finite element discretization of continuum, Shape functions, Element matrices, Finite element methods for boundary value problems of ordinary and partial differential equations.

Practical: Practical on numerical computation of the problems based on the above methods using a programming language or software.

Suggested Reading:

1. Jain & Iyengar Computational Methods for Partial Differential Equations, Wiley Eastern.
2. J. N. Reddy An Introduction to the Finite Element Method, McGraw Hill Inc.
3. Daryl L. Logan A First Course in the Finite Element Method, Cengage Learning.
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MTPC-154 Operations Research

Game Theory: Two person zero sum games, Games with mixed strategies, Graphical solution, Solution by linear programming.

Integer Programming, Mixed Integer Programming, Sensitivity Analysis.

Programming: Stochastic Linear and Stochastic Non-Linear Programming. Network Scheduling by PERT/CPM.

Suggested Reading:

1. G. Hadley Nonlinear and Dynamic Programming, Addison Wesley.
2. H. A. Taha Operations Research - An Introduction, Macmillan.
3. Kanti Swarup, P. K Gupta and Man Mohan. Operations Research, Sultan Chand & Sons, New Delhi
4. S. S. Rao. Optimization Theory and Applications, Wiley Eastern.
5. N. S. Kambo Mathematical Programming Techniques Affiliated East -West Press Pvt. Ltd., New Delhi.

MTPC-155 Integral Equations

Classification, Modeling of problems as integral equations. Conversion of initial value and boundary value problems into integral equations. Conversion of integral equations into differential equations, Volterra integral equations and their numerical solutions. Greens function for Fredholm integral equation of second kind. Fredholm integral equations: Degenerate kernels, Symmetric kernels. Fredholm integral equation of second kind. Numerical solution of Fredholm integral equations.

Existence of the solutions: Basic fixed point theorems.

Integral equations and transformations: Fourier, Laplace and Hilbert transformation.

Suggested Reading

1. Abdul J. Jerry Introduction to Integral Equations with Application, Marcel Dekkar.
2. L. G. Chambers Integral Equations: A short Course, Int. Text Book Company
3. R.P. Kanwal Linear Integral Equations
4. Harry Hochsdedt Integral Equation.
5. Murray R. Spiegel Laplace Transform, Schaums Outline

MTPC-156 Fuzzy Sets and Applications

Basic concepts of Fuzzy sets and Fuzzy logic: Motivation, Fuzzy sets and their representations, Membership functions and their designing, Types of Fuzzy sets, Operations on fuzzy sets, Convex fuzzy sets, Alpha level cuts, Geometric representations of Fuzzy sets, Linguistic variables Possibility measure and distribution, Fuzzy members , Arithmetic operations on fuzzy numbers.

Suggested Reading:

1. H. J. Zimmermann Fuzzy Set Theory and its Applications, Kluwer Academic Publisher.

MTPC-157 Graph Theory

Matching, covering, Connectivity, Planar graphs: Kuratowski's theorem, Algebraic planarity criteria, Coloring, Matrix representation of graphs.

Ramsey theory for graphs, Graph labeling: α - labeling, β - labeling, γ - labeling, κ - graceful labeling, Harmonious labeling, Radio- labeling, Magic labeling.

Suggested Reading:

1. J.A. Gallian A Dynamic Survey of Graph Labeling, The Electronic Journal of Combinatorics, 16(2009), #DS6.
2. Douglas B. West Introduction to Graph Theory, PHI
3. Narsingh Deo Graph Theory with Applications to Engineering and Computer Science, PHI 2005.
4. Frank Harary Graph Theory, Narosa Pub.
5. Reinhard Diestel Graph Theory, Springer

MTPC-158 Mathematical Modeling

The Modeling Process: The real world systems and the mathematical world, Mathematical models and their nature, Construction of mathematical models, The iterative nature of model, Construction, Characteristics of mathematical models.

Mathematical models in Pharmacokinetics: Compartment, n-Compartment system, Special cases of single and double compartment system.

Blood Flow: Introduction, Modeling blood flow: Viscosity, Poiseuille Law, Formulation, Interpretation and limitations.

Suggested Reading:

1. Giordano Weir and Fox A First Course in Mathematical Modeling, Brooks/Cole (ITP).
2. J.N. Kapur Mathematical Models in Biology and Medicine, EWP.
3. IGNOU Mathematical Modeling in Biological Environment, Vol. - 3.

MTPC-159 Probability and Statistics

Probability, Random Variables and Probability Distributions, Estimation, Hypothesis Testing, Curve Fitting, Correlation and Regression, Chi-square Test, t-Test, Z-Test

Suggested Reading:

1. Miller and Freund Probability and Statistics for Engineers and Scientists, PHI.
2. J. Medhi Statistical Methods: An Introduction Text, New Age International.

MTPC-160 Wavelet Transforms and Their Applications

The Fourier transform and its inverse Fourier transform. Brief historical introduction to the wavelets, Definitions of wavelets and examples, Continuous wavelet transforms and examples, Basics properties of wavelet transforms, Parseval's formula for wavelet transform, Inversion theorem for wavelet transform. The Discrete wavelet transforms and examples, Orthonormal wavelets and its examples, Approximation of Square Integrable Functions Using Wavelet Bases.

Refinement equation and examples, Dyadic number, Definition of Multiresolution Analysis (MRA) and examples, Properties of scaling functions and orthonormal wavelets bases, Orthonormalization process, Construction of orthonormal wavelets (Some basic Examples), Daubechies wavelets (D4, D6) and some examples.

Books Prescribed:

- 1.L. Debnath Wavelet transforms and Their Applications, Birkhauser, Boston, 2002 (Chapter 1, 2, 6, 7 and 8).
2. K. P. Soman Insight Into Wavelets From Theory To Practice (3rd Edition), PHI Learning Private Limited (For D4 and D6 Only).

Books Recommended:

- 1.A. Boggess and F. J. Narcowich A First Course in Wavelets with Fourier Analysis, Prentice Hall.
- 2.C. K. Chui An Introduction to Wavelets, Academic Press, New York, 1992.
- 3.G. Kaiser A Friendly Guide to Wavelets, Birkhauser, Boston, 1994.
- 4.I. Daubechies Ten Lectures on Wavelets, SIAM Publ., (1992), 326.