M.Phil / Ph.D Mathematics **2020-2021**

Paper-I

20RMAT101 RESEARCH METHODOLOGY AND PEDAGOGY 4H – 4C

Instruction Hours / week: L: 4 **Total: 100**

End Semester Exam: 3 Hours

Course Objective:

This course enables the students to

1. Understand research terminology.
2. The ethical principles of research, ethical challenges and approval processes.
3. Describe quantitative, qualitative and mixed methods approaches to research.
4. Identify the components of a literature review process.
5. Critically analyze published research.

Course Outcomes (Cos):

After completing this course, the student will be able to:

1. The basic framework of research process.
2. Develop an understanding of various research designs and techniques.
3. Know about the violation of publication ethics , authorship and contributing and appeals.
4. An understanding of the ethical dimensions of conducting applied research.
5. Appreciate the components of scholarly writing and evaluate its quality.

UNIT – I

Research Methodology – Meaning of research, Objectives of Research, Motivation in Research – Types of Research – Research approaches – Research methods, Versus Research Methodology – Research process – Scientific method – Criteria for good research, Defining the research problem – Necessity of defining the problem – Techniques involved in defining the problem, Research Design – Meaning and need for Research Design – Features of good design – Important concepts relating to research design.

UNIT – II

Implicit functions and extremum problems: Introduction – Functions with non zero Jacobian determinant – Inverse function theorem – Implicit function theorem – Extrema of real valued functions of one variable and several variables. Rank Theorem – Determinants – Derivatives of Higher order-Differentiation of Integrals.

UNIT – III

Oscillations of second order equation-Fundamental results – Sturms comparison theorem – elementary linear oscillations – comparison theorem of Hille winter – Oscillations of $x'' + a(t)x = 0$ elementary non linear oscillations – stability of linear and non linear systems – elementary critical points – system of equations with constant coefficient – the linear equations with constant co efficient – Lyabunov stability – Stability of quasi linear systems.

UNIT- IV

LATEX: The Basics - The Document -Bibliography - Bibliographic Databases - Table of contents, Index and Glossary - Displayed Text - Rows and Columns -Typesetting Mathematics - Typesetting - Several Kinds of Boxes - The figure environment -Cross References in LATEX - Footnotes, Marginpars, and Endnotes.

UNIT-V

Objectives and roll of higher education – Important characteristics of an effective Lecture – Quality teaching and learning – Lecture preparation – Characteristics of instructional design – Method of teaching and learning: Large group – Technique – Lecture, Seminar, Symposium, Team Teaching, Project, Small group Technique – Simulation, role playing Demonstration, Brain Storing, case discussion and assignment, Methods of evaluation – Self evaluation, Student evaluation, Diagnostic testing and remedial teaching – Question banking – Electronic media in education: e-learning researches – web based learning.

SUGGESTED READINGS

1. Kothari, C. R., (2014). Research Methodology, Method and Techniques, Second Edition, New age International publishers, New Delhi.
2. Rudin. W., 2016. Principles of Mathematical Analysis, McGraw Hill, New York.
3. Earl A. Coddington, (2002). An introduction to Ordinary Differential Equations, Prentice Hall of India Private limited, New Delhi. (For Unit III)
4. Krishnan E., (Sep 2003). Latex Tutorials – A primer, Indian TEX users group, Trivandrum, India.
5. Panneerselvam. R, (2013). Research Methodology, Second Edition, Prentice Hall of India, New Delhi.
6. Gupta. S. P, (2011). Statistical Methods, Fourth Edition,Sultan Chand & Sons, New Delhi.
7. Vedanayagam E. G (2019). Teaching Technology for College teachers, New Delhi.
8. Kumar. K. L. (2004). Educational Technologies, New age International, New Delhi:
9. Winkler, Anthony C., and Jo Roy McCuen (2015). Writing a research paper: A Handbook, 2nd edition, Harcourt, New York.

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Paper-II

20RMAT201 RESEARCH AND PUBLICATION ETHICS 4H – 4C

Instruction Hours / week: L: 4 **Total: 100**

End Semester Exam: 3 Hours

Course Objective:

This course enables the students to

1. Know about the basic of philosophy of science and ethics, research integrity, publication ethics
2. Know about the hands on sessions are designed to identify misconduct and predatory publications.
3. Learn indexing and citation databases, open access publication, research and p metrics and plagiarism tools introduced in the course.

Course Outcomes (Cos):

After completing this course, the student will be able to:

1. The basic concept and moral philosophy of research process.
2. Understand selective reporting and misrepresentation of date.
3. Identify violation of publication ethics , authorship and contributing and appeals
4. Know about the indexing database and impact factor of journals.

UNIT I: Philosophy and Ethics

Introduction to Philosophy: Definition, nature and scope, concept, branches – Ethics: Definition, moral philosophy, nature of moral judgments and reaction.

UNIT II: Scientific Conduct

Ethics with respect to science and research – Intellectual honesty and research integrity – scientific misconduct: Falsification – Fabrication – Fabrication and Plagiarism (FFP) – Redundant publications: duplicate and overlapping publication-salami slicing- selective reporting and misrepresentation of date.

UNIT III: Publication Ethics

Publication Ethics: Definition, introduction and importance- Best practices/ standards setting initiatives and guidelines: COPE, WAME, etc. – Conflicts of interest – publication misconduct: definition, concept , problems that lead to unethical behavior and vice versa,

type- violation of publication ethics , authorship and contributing and appeals- predatory publishers and journals.

UNIT IV: Publication misconduct

Group discussions: Subject specific ethical issues, FFP, authorship – conflicts of interest- complaints and appeals : examples and fraud from India and abroad.

UNIT V: Development of e-content &IPR

Database: indexing database- citation database: web of science,scopus, etc.

Research Metrics: impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score – Metrics: h-index, g index, g index, I 10 indices, altmetrics.

UNIT VI: Development of e- content & IPR

Integrated Library Management System (ILMS): e-journals – e-books – e-shodhsindu – shodhganga – database – e-content development – Learning Management system (LMS) – e-PG – Pathshala – CEC (UG) SWAYAM – MOOCs – NPTEL – NMEICT. IPR: Patent – Copyrights- trademark – Geographical Indication.

PRACTICE:
Open access publishing
Open access publications and initiatives-SHERPA/RoMEO online resource to check polisher copyright & self -archiving policies-software tool to identify predatory publications developed by SPPU-Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

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Paper-III

20RMAT301 **FUZZY MATHEMATICS** **4H – 4C**

Instruction Hours / week: L: 4 **Total: 100**

End Semester Exam: 3 Hours

Course Objective:

This course enables the students to

1. Provide an understanding of the basic mathematical elements of the theory of fuzzy sets.
2. Provide an emphasis on the differences and similarities between fuzzy sets and classical sets theories.
3. Explain the concepts of crisp set, fuzzy logic and fuzzy graphs.
4. To teach the students the need of fuzzy sets, arithmetic operations on fuzzy sets, fuzzy relations, Fuzzy measures, Decision making in fuzzy environments.
5. Enable students to solve problems that are appropriately solved by neural networks, fuzzy logic, and genetic algorithms.

Course Outcomes (Cos):

After completing this course, the student will be able to:

1. Understand about the concepts of fuzzy sets and fuzzy logic
2. Acquire the knowledge on general aggregation operations
3. Know about the fuzzy relation equation and fuzzy graphs
4. Describe the probability measures and fuzzy measures of fuzziness
5. Import the knowledge on the Decision making in fuzzy environments.

UNIT - I

Crisps sets and Fuzzy sets: Introduction –Crisp Sets: An overview-The notion of fuzzy sets – Basics concepts of fuzzy sets –Classical logic: An overview-Fuzzy logic.

UNIT- II

Operations on Fuzzy sets: Fuzzy complement - fuzzy union – fuzzy Intersection – combinations of operation – General Aggregation operations.

UNIT - III

Fuzzy relations and Fuzzy graphs: Crisp and fuzzy relations – Binary relations-Binary relations on a single set – Equivalence and similarity relations-Compatibility or Tolerance relations – ordering- Morphisms – Fuzzy relation equations – Fuzzy graphs.

UNIT- IV

Fuzzy Measures: Belief and Plausibility Measures – Probability Measures – Possibility and necessity measures-Relationship among classes of Fuzzy measures of Fuzziness.

UNIT- V

Decision making in fuzzy environments: Fuzzy Decisions – Fuzzy Linear programming – symmetric Fuzzy LP – Fuzzy LP with crisp objective function – Fuzzy Dynamic Programming-Fuzzy Dynamic with Crisp state Transformation Function- fuzzy multi criteria Analysis– Multi objective Decision Making (MODM) – Multi Attributive Decision making (MADM).

SUGGESTED READINGS

1. George J.Klir and Tina A.Folger., (2015). Fuzzy sets – Uncertainty and information, Prentice – Hall of India Pvt. Ltd. Chapters: I, II, III & IV.
2. Zimmermann H.J.,(2007). Fuzzy set theory and its applications , Fourth Edition Springer . Chapter XIV.

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Paper-III

20RMAT302 **ADVANCED TOPICS IN FLUID DYNAMICS** **4H – 4C**

Instruction Hours / week: L: 4 **Total: 100**

End Semester Exam: 3 Hours

Course Objective:

This course enables the students to

1. Develop an appreciation for the properties of two dimensional flow.
2. Understand the dynamics of fluid flows and the governing non dimensional parameters.
3. Apply the concept of equation of motion in rotating co-ordinate system.
4. Describe the main properties of the system of equations.
5. Understand the system of Magnetohydrodynamics equations and main theorems that follow from the Magnetohydrodynamics system.

Course Outcomes (Cos):

After completing this course, the student will be able to:

1. Classify and exploit fluids based on the physical properties of a fluid.
2. Compute correctly the kinematical properties of a fluid element.
3. Apply correctly the conservation principles of mass, linear momentum, and energy to fluid flow systems.
4. Understand both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.
5. Provide the student with the basic mathematical background and tools to model fluid motion.
6. Calculate the flow of an ideal fluid in a variety of situations.
7. Develop a physical understanding of the important aspects that govern fluid flows that can be observed in a variety of situations in everyday life.

UNIT – I

Steady unidirectional flow – Poiseuille flow – Two dimensional flow – Paint-Brush model – unsteady unidirectional flow – Flow with circular stream lines – Flow fields in which inertia forces are negligible – Lubrication theory.

UNIT – II

Thermal boundary layer in laminar flow: Derivation of the energy equation – Temperature increase through adiabatic compression – Stagnation temperature – Theory of similarity in heat transfer – Exact solutions for the problem of temperature distribution in a viscous flow – Boundary layer simplifications.

UNIT – III

Equation of motion in rotating co-ordinate system – Potential vorticity – vorticity equation – Ertel's theorem – Non dimensional parameters – Rossby number – Ekman number – Geostrophic flow – Taylor – Proudman theorem – Taylor coloumn.

UNIT – IV

Magnetohydrodynamics: Electrodynamics of moving media – The electromagnetic effects and the magnetic Reynolds number – Alfen's theorem – The magnetic energy – The mechanical equations – Basic equations for the incompressible MHD – Steady Laminar motion – Hartmann flow.

UNIT – V

Magnetohydrodynamic waves – waves in an infinite fluid of infinite electrical conductivity – Alfen's waves – Magnetohydrodynamic waves in a compressible fluid – Magneto acoustic waves – Slow and Fast waves – Stability – Physical concepts – Linear-Pinch –Kink – Sausage and Flute types of instability – Method of small oscillations – Jeans criterion for gravitational stability.

SUGGESTED READINGS

1. Batchelor. G.K.,(2002). An Introduction to Fluid Dynamics, Cambridge University Press.
2. Schlichting. H.,(2003). Boundary – Layer Theory, Springer.
3. Friedlander. S.,(2080). An Introduction to the Mathematical Theory of Geophysical Fluid Dynamics, Elsevier.
4. Ferraro .V.C.A and Plumpton. C.,(2072). An Introduction to Magneto Fluid Dynamics, Oxford University.

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Paper-III

20RMAT303 HYDRODYNAMIC AND HYDROMAGNETIC STABILITY 4H – 4C

Instruction Hours / week: L: 4 **Total: 100**

End Semester Exam: 3 Hours

Course Objective:

This course enables the students to

1. Learn the concept of stability of hydrodynamics systems.
2. Understand the concept of important instabilities like Rayleigh-Taylor, Kelvin-Helmholtz instability.
3. Learn the Perturbation Techniques for determining the stability of superposed fluids.
4. Analyze the analytical technique to characterize the hydrodynamic stability.

Course Outcomes (Cos):

After completing this course, the student will be able to:

1. Describe the fundamental principles of the motion of ideal (inviscid) and real (viscous) fluid flows.
2. Apply analytical concepts to analyse a range of two-dimensional engineering fluid flows, with appropriate choice of simplifying assumptions and boundary conditions.
3. Provide the details of the derivation of ideal and resistive HD equations.
4. Demonstrate the basic properties of ideal HD.
5. Describe electromagnetic fields.

UNIT – I: Introduction:

Basic Concepts - Analysis in terms of normal modes - Non-dimensional number.

UNIT – II: Benard Problem:

Basic hydrodynamic equations. Boussinesq approximation .Perturbation equations. Analysis into normal modes. Principle of exchange of stabilities. Equations governing the marginal state. Exact solution when instability sets in as stationary convection for two free boundaries.

UNIT – III

The effect of rotation: The Perturbation equations. Analysis in terms of normal modes. Variation Principle for stationary convection. Solutions when instability sets in as stationary convection for two free boundaries. On the onset of convection as over stability; the solution for the case of two free boundaries.

UNIT – IV

The effect of magnetic field: The Perturbation equations. The case when instability sets in as stationary convection; A variational principle. Solutions forstationary convection and for over stability for the case of two free boundaries. **The stability of superposed fluids.**

UNIT – V

(i) **Rayleigh-Taylor instability:** The Perturbation equations. Inviscid case(the case of two uniform fluids of constant density separated by a horizontal boundary, the case of exponentially varying density). Effect of rotation. Effect of vertical magnetic field.

(ii) **The Kelvin-Helmholtz instability:** The perturbation equations, the case of two uniform fluids in relative horizontal motion separated by a horizontal boundary, the effect of rotation, the effect of horizontal magnetic field.

SUGGESTED READINGS

1. Chandrasekhar. S.,(2081). Hydrodynamic and Hydromagnetic Stability, Dover Publications.

2. Drazin. P.G and Reid. W.H.,(2004). Hydrodynamic Stability, Cambridge University Press.

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Paper-III

20RMAT304 **QUEUEING THEORY** **4H – 4C**

Instruction Hours / week: L: 4 **Total: 100**

End Semester Exam: 3 Hours

Course Objective:

This course enables the students to

1. Develop the modeling and mathematical skills to analytically determine computer systems and analytically determine computer systems and communication network performance.
2. Read and understand the current performance analysis and queueing theory literature upon completion of the course.
3. Understand strengths and weaknesses of Queueing Models

Course Outcomes (Cos):

After completing this course, the student will be able to:

1. Construct models in discrete and continuous time based on Markov Chains
2. Describe and motivate Little's formula and its applications
3. Describe and analyze basic Markov queuing models and situations to which they may be applied
4. Basic characteristic features of a queuing system and acquire skills in analyzing queuing models.

UNIT I

Introduction-Markov Chains- Basic ideas-Classification of states and chains-Sojourn time - Transition density matrix or infinitesimal generator - Limiting behavior: ergodicity - Transient solution -Alternative definition.

UNIT II

Birth-and-Death Processes: Special case: M/M/1 queue -Pure birth process-Yule-Furry process. Queueing Systems: General Concepts: Basic characteristics -The input or arrival pattern of customers -The pattern of service -The number of servers -The capacity of the system - The queue discipline. The Simple M/M/1 Queue : Steady-state solution of M/M/l - Waiting-time distributions - The output process -Semi-Markov process analysis.

UNIT III

System with Limited Waiting Space: The M/M/1/K Model: Steady-state solution - Expected number in the system L_K - Equivalence of an M/M/l//K model with a two-stage cyclic model - Birth-and-Death Processes: Exponential Models - The M/M/∞ Model: Exponential Model with an Infinite Number of Servers.

UNIT IV

The Model M/M/c : Steady-state distribution - Expected number of busy and idle servers - Waiting-time distributions - The output process .The M/M/c/c System: Erlang Loss Model: Erlang loss (blocking) formula: Recursive algorithm -Relation between Erlang's B and C formulas .

UNIT V

Model with Finite Input Source : Steady-state distribution: M/M/c//m (m>c). Engset delay model- Engset loss model M/M/c//m/(m > c) - The model M/M/c//m(m $\leq$ c).

SUGGESTED READINGS

1. Medhi J., (2003). Stochastic models in Queueing theory, 2e, Academic press.
2. Donald Gross, John F. Shortle , James M.Thompson , Carl M., and Harris , (2008). Fundamentals of Queueing theory, Wiley.
3. Narayan Bhat U.,(2008). An introduction to Queueing theory: Modelling and Analysis in Applications, Birkhauser Basel.

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Paper-III

20RMAT305 **ADVANCED GRAPH THEORY** **4H – 4C**

Instruction Hours / week: L: 4 Total**: 100**

End Semester Exam: 3 Hours

Course Objective:

This course enables the students to

1. Study the concept of an integral part of Discrete Mathematics and has applications in diversified areas such as Electrical Engineering, Computer science, Linguistics.
2. Apply theoretical knowledge acquired to solve realistic problems in real life.
3. Learn the applicability of theoretical concepts to address network design problems.

Course Outcomes (Cos):

After completing this course, the student will be able to:

1. Understand the concept of Connectivity and coloring of graphs
2. Domination number and Crossing number is used to design the safe of digital circuits
3. Understand the concept of factorization and decomposition.
4. Study the Generalized Ramsey theory, Rainbow Ramsey numbers and the probabilistic method.

UNIT-I:

Coloring of Graphs

Vertex coloring and upper bounds – Brook's Theorem – Graphs with large chromatic number – Turan's Theorem – Counting proper coloring – Edge coloring – Characterization of line graph

UNIT-II:

Dual Graphs

Embeddings and Euler's Formula – Dual graphs – Kuratowski's Theorem – Five color theorem – Crossing number – Surface of higher genus

UNIT-III:

Decomposition and Labeling

Factorizations and Decompositions of graphs- Labeling of Graphs

UNIT-IV:

Domination

Domination Theory -The Domination number of a graph- Bounds in terms of degree- The Independent Domination number of a graph

UNIT-V:

Ramsey Theory

Classical Ramsey numbers- Generalized Ramsey Theory.

REFERENCES:

- G. Chartrand, L. Lesniak, Graphs and Digraphs, Chapman and Hall/CRC, New York, 2016.
- Douglas B. West, Introduction to Graph Theory, Prentice Hall of India, 2002.
- Bondy J. A. and Murty U. S. R, Graph Theory, Springer, 2008.
- Harary F, Graph Theory, Addison-Wesley Publication, 1972.
- Deo N, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India, 2016.