Syllabus of Ph.D. Coursework

[Effective from the Academic Session 2020-2021]

JIS UNIVERSITY,
81, Nilgunj Road, Agarpara
Kolkata -700109

DEPARTMENT OF MATHEMATICS

CREDIT DISTRIBUTION OF Ph.D. COURSE WORK

Compulsory Papers								
COURSE TYPE	**SUBJECT CODE**	**SUBJECT NAME**	**L**	**T**	**P**	**CREDIT**	**CONTACT HOURS**	**MARKS DISTRIBUTION**
CORE	RPD1001	RESEARCH METHODOLOGY	**4**	**0**	**0**	4	4	100
CORE	RPD1002	RESEARCH AND PUBLICATION ETHICS	**2**	**0**	**0**	2	2	50
		TOTAL	**6**	**0**	**0**	6		
Elective Papers (Any Two)								
ELECTIVE	RMT1001	INTRODUCTION TO OPERATIONS RESEARCH	**3**	**1**	**0**	4	4	100
ELECTIVE	RMT1002	INTRODUCTION TO FUZZY SYSTEMS AND APPLICATIONS	**3**	**1**	**0**	4	4	100
ELECTIVE	RMT1003	SPECTRAL GRAPH THEORY	**3**	**1**	**0**	4	4	100
ELECTIVE	RMT1004	ADVANCED LINEAR ALGEBRA	**3**	**1**	**0**	4	4	100
		TOTAL	**6**	**2**		**8**	**4**	

DETAILED SYLLABUS

RPD1001: RESEARCH METHODOLOGY

L-T-P: 4-0-0
Credit: 4

I. Research-Definition, Objectives of Research, What Makes People do Research? Qualities of a good Researcher, Limitations of Research, Views of Researchers, Scientific method of Research, Importance of Research, Illustrations of Research.

II. Process of Research. Research Methods, Research Methods versus Research Methodology. Fundamental or Basic Research and Examples, Applied Research and Examples, differences between Basic Research and Applied research. Difference between Approach and Validity, Reliability versus Unbiased and objective, Research structured enquiry, Research Design.

III. Normal, Revolutionary, Quantitative, and Qualitative Research Methods. Learning from Qualitative and Quantitative Research. Data Collection, Generation of Data using Qualitative Methods: (Individual Interviews, Focus groups, Observations, Self-Study, Action Research), Sources of Quantitative Data, Analyzing Quantitative Data, Pros and Cons of Qualitative research, Comparing Quantitative and Qualitative Research, Example and Distinction, Important Difference, Qualitative research, Descriptive Versus Analytical, Conceptual Versus Empirical, Decision-oriented versus Conclusion-oriented,

IV. Process of literature Survey, Advantages and Pitfalls. The Internet as a Medium for Research, Availability of Scientific Research Information, Problems Encounter, Features of Conducting Research through Internet, New Challenges to Researchers, Potential Advantages of Online Questionnaire, Potential Difficulties, Preservation of References, Assessing the Current Status.

V. Ethics in Research, Computer Ethics, some areas of Research Ethics, Essential information required for authority, Author Responsibilities, what is not acceptable? What are Plagiarism and Self-Plagiarism, Other Types of Ethical Violations, How Journals Detect and Handle Problem Papers? Example, Reasons for possible Plagiarism, appropriate authorship.

VI. Seminar, Oral Report, Quotation, Points to be Remembered in Preparing an Oral Report, Write-up of the oral presentation, Art of writing and layout of Research Paper or Article or Ph. D. Thesis. Main Text, End Matters, Content of work.

References:

1. Ander May, R., Meyer, V., Van Rys, J., Kemper, D., & Sebranek, P. (2016). The College Writer: A Guide to Thinking, Writing, and Researching, MIT Press.
2. Gustavii, B. (2014). How to Write and Illustrate a Scientific Paper. New York, NY: Cambridge.
3. Kothari, C.K. (2015). Research Methodology – Methods and Techniques. New Age International, New Delhi.
4. Krishnswamy, K.N., Shivkumar, AppaIyer, &Mathiranjan M. (2013). Management Research Methodology: Integration of Principles, Methods, and Techniques. Pearson Education, New Delhi.
5. G. Vijaylakshmi and C. Sivapragasam (2008). Research Methods: Tips and Techniques. MJP Publishers, Chennai.

RPD1002: RESEARCH AND PUBLICATION ETHICS

L-T-P: 2-0-0
Credit: 2

I. PHILOSOPHY AND ETHICS

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions

II. SCIENTIFIC CONDUCT

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

III. PUBLICATION ETHICS

1. Publication ethics: definition, introduction and importance
2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

IV. OPEN ACCESS PUBLISHING

1. Open access publications and initiatives
2. SHERPA/RoME0 online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU

V. Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

VI. PUBLICATION MISCONDUCT

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest

3. Complaints and appeals: examples and fraud from India and abroad

4. Use of plagiarism software like Turnitin, Urkund and other opensource software tools

VII. DATABASES AND RESEARCH METRICS

1. Indexing databases

2. Citation databases: Web of Science, Scopus, etc.

VIII. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score

Metrics: h-index, g index, il 0 index, altimetric

References:

1. Ander May, R., Meyer, V., Van Rys, J., Kemper, D., & Sebranek, P. (2016). The College Writer: A Guide to Thinking, Writing, and Researching, MIT Press.

2. Gustavii, B. (2014). How to Write and Illustrate a Scientific Paper. New York, NY: Cambridge.

3. Kothari, C.K. (2015). Research Methodology – Methods and Techniques. New Age International, New Delhi.

4. Krishnswamy, K.N., Shivkumar, AppaIyer, &Mathiranjan M. (2013). Management Research Methodology: Integration of Principles, Methods, and Techniques. Pearson Education, New Delhi.

5. G. Vijaylakshmi and C. Sivapragasam (2008). Research Methods: Tips and Techniques. MJP Publishers, Chennai.

RMT1001: Introduction to Operations Research

L-T-P: 3-1-0
Credit: 4

No. of lectures: 48

Course objective:
In this course the students will learn about the basic knowledge of LPP, duality, transportation
problem, assignment problem, game theory, queueing and inventory models. At the end of
the course, the students will get knowledge about various decision making through operations
research models.

Course Outcomes:
CO1: To explain linear programming problems and appreciate their limitations.
CO2: To analyze and solve linear programming problems using appropriate techniques and optimization solvers.
CO3: To conduct and interpret post-optimal and sensitivity analysis and explain the primal- dual relationship.
CO4: To develop mathematical skills to analyze and solve transportation, assignment problem and network models arising from a wide range of applications.
CO5: To develop mathematical knowledge to analyze and solve real life problems.

Module I
Linear Programming Problem(LPP): Operations Research and its Scope, Necessity of Operations Research in industry Mathematical formulation of linear programming problem, Linear Programming and examples, Convex Sets, Hyper plane, Open and Closed half-spaces, Feasible, Basic Feasible and Optimal Solutions, Extreme Point & graphical methods. Simplex method, Big-M method, Duality theory, Dual linear Programming Problems, Fundamental properties of dual problems, Complementary slackness, unbounded solution in Primal. Transportation Problem, Assignment Problem.

Module II
Game Theory: Introduction**;**Two person Zero Sum game, Saddle Point; Mini-Max and Maxi-Min Theorems (statement only) and problems; Games without Saddle Point; Graphical Method; Principle of Dominance.

Module III
Network Optimisation Models: CPM / PERT (Arrow network, Time estimates, earliest expected time, latest allowable occurrence time, latest allowable occurrence time and stack. Critical path, Probability of meeting scheduled date of completion of project.Calculation of CPM network.Various floats for activities.

Module IV
Queuing Theory and Inventory Control : Introduction and Basic Structure of Queuing Theory; Basic Definations and Notations; Birth-and-Death Model (Poisson /

Exponential distribution); Poisson Queue Models: (M/M/1):(∞/FIFO) and (M/M/1):(N/FIFO) and Problems.
Determination of EOQ, Components, Deterministic Continuous &Deterministic Periodi c ReviewModels, Stochastic Continuous & Stochastic Periodic Review Models.

Recommended books:

1. H. A. Taha, *Operations Research - An Introduction*, Macmillan Publishing Company Inc., New York, 2006.

2. K. Swarup, P. K. Gupta, and M. Mohan, *Operations Research*, Sultan Chand & Sons, New Delhi, 2001.

3. S. M. Sinha, *Mathematical Programming, Theory and Methods,* Delhi: Elsevier, 2006.

4. N. S. Kambo, *Mathematical Programming Techniques*, Affiliated East- West Press Pvt. Ltd., 1984, Revised Edition, New Delhi, 2005.

5. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 1987.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	-	-	1
CO2	3	2	2	-	-	-	-	-	-	-	-	1
CO3	3	3	2	-	-	-	-	-	-	-	-	1
CO4	3	3	2	-	-	-	-	-	-	-	-	1
CO5	3	3	2	-	-	-	-	-	-	-	-	1

ELECTIVE PAPER

RMT1002: Introduction to Fuzzy Systems and Applications

L-T-P: 3-1-0
Credit: 4

No. of lectures: 48

Course Objectives:
CO1: Interpret fuzzy set theory and uncertainty concepts
CO2: Identify the similarities and differences between probability theory and fuzzy set theory and their application conditions
CO3: Apply fuzzy set theory in modeling and analyzing uncertainty in a decision problem
CO4: Design fuzzy systems for various engineering applications
CO5: Analyse the performance of fuzzy systems

Module-I: Fuzzy set theory
Introduction, Fuzzy versus crisps, Number system, Interval, Sets, Representation of a set, Types of sets, Subsets, Universal sets, Venn diagram, Operations on sets, Difference of two sets, Some important results, Fuzzy sets, Types of Fuzzy sets, General definitions and properties of Fuzzy sets, alpha-level sets, convex fuzzy sets,

Module-II: Operations on fuzzy sets
Introduction, Extension principle of Fuzzy sets, Fuzzy complement, basic operations on fuzzy sets, types of fuzzy sets, Cartesian products, algebraic products, bounded sum and difference, t-norms and t-conorms, Definition of intersection and union by Hamacher, Yager's Union and intersection of two sets, Union and intersection of two fuzzy sets as defined by Dubois and Prade Aggregation operations,

Module-III: Fuzzy number and arithmetic

Introduction, Fuzzy numbers, Algebraic operations on fuzzy numbers, Binary operation of to fuzzy number, Extended operations for L-R representation of Fuzzy sets, Fuzzy arithmetic operations on fuzzy number in the form of Alpha cut set, Fuzzy equations.

Module-IV: Fuzzy Relations and Decision making in fuzzy environment

Introduction, projections and cylindrical fatty relations, Compositions, Binary relation on a single set, Compatibility relations, Introduction, Individual decision making, Multi person decision making, Multi criteria decision making, Fuzzy Ranking method, Fuzzy linear programming

Recommended books:

1. A. Kaufmann and M.M. Gupta, Introduction to fuzzy Arithmetic Theory and Application (Van Nostrand Reinhold, New York, 1991).
2. A. Kaufmann and M. M. Gupta, Fuzzy Mathematical Model in Engineering and Management Science, North-Holland, 1988.
3. Dubois D., Prade H.: Fuzzy Sets and Systems: Theory and Applications. Academic Press, New York, (1980)
4. Hans-Jürgen Zimmermann, Fuzzy set theory and its application, Springer; 2nd edition (January 31, 1991)
5. George Bojadziev, Maria Bojadziev, Fuzzy Sets, Fuzzy Logic, Applications, World Scientific, 1995
6. Lotfi A. Zadeh, Fuzzy Sets, Fuzzy Logic, And Fuzzy Systems: Selected Papers,World Scientific 1996.

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	-	-	1
CO2	3	2	2	-	-	-	-	-	-	-	-	1
CO3	3	3	2	-	-	-	-	-	-	-	-	1
CO4	3	3	2	-	-	-	-	-	-	-	-	1
CO5	3	3	2	-	-	-	-	-	-	-	-	1

RMT1004: Advanced Linear Algebra

L-T-P: 3-1-0
Credit: 4

No. of lectures: 48

Course Description

This course explores the deep structures and advanced concepts in linear algebra, with an emphasis on vector spaces, matrix theory, eigenvalue problems, and applications in geometry, optimization, and functional analysis. It provides a rigorous approach to the theory and methods of linear algebra and prepares students for advanced research in algebra, topology, and other fields.

Course Objectives

Upon successful completion of the course, students will be able to:

CO1: Understand the advanced properties of vector spaces, linear transforma- tions, and inner product spaces,

CO2: Master the theory of eigenvalues and eigenvectors, including their use in diagonalization, spectral theory, and quadratic forms,

CO3: Apply advanced methods of matrix theory in solving systems of linear equations, analyzing stability, and optimizing linear systems,

CO4: Explore the connections between linear algebra and other areas of mathematics, such as functional analysis and geometry,

CO5: Develop research skills and problem-solving techniques involving advanced linear algebra

Module 1: Vector Spaces and Linear Transformations

Vector spaces, subspaces, linear independence, basis and dimension, rank-nullity theorem, linear transformations and their matrix representations, null space, column space, and row space, dual spaces and duality, isomorphisms between vector spaces.

Module 2: Eigenvalues and Diagonalization

Eigenvalue problems: definition and properties, characteristic polynomial, geometric and algebraic multiplicity, diagonalization of matrices, Jordan canonical form, spectral theorem for normal operators, applications in stability analysis, orthogonal diagonalization and symmetric matrices.

Module 3: Inner Product Spaces and Orthogonality

Inner product spaces: definition, properties, and examples, Gram-Schmidt orthogonalization, orthogonal projections, orthonormal bases, orthogonal diagonalization, Rayleigh quotient, spectral theorem for self-adjoint operators, applications to quadratic forms and optimization.

Module 4: Advanced Matrix Theory

Singular value decomposition (SVD), principal component analysis (PCA), matrix decompositions: LU, QR, Cholesky, Schur decomposition, applications to numerical methods, least squares problems, condition number and stability analysis, the pseudoinverse and Moore-Penrose inverse.

References

1. Axler, S. – *Linear Algebra Done Right*, 3rd Edition, Springer, 2015.
2. Strang, G. – *Introduction to Linear Algebra*, 5th Edition, Wellesley-Cambridge Press, 2016.
3. Horn, R. A., and Johnson, C. R. – *Matrix Analysis*, 2nd Edition, Cam- bridge University Press, 2013.
4. Gray, A. – *Linear Algebra: A Geometric Approach*, 2nd Edition, Springer, 2011.
5. Gelfand, I. M. – *Lectures on Linear Algebra*, Dover Publications, 2013.

COPO-mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	-	-	1
CO2	3	2	2	-	-	-	-	-	-	-	-	1
CO3	3	3	2	-	-	-	-	-	-	-	-	1
CO4	3	3	2	-	-	-	-	-	-	-	-	1
CO5	3	3	2	-	-	-	-	-	-	-	-	1

RMT1003 Spectral Graph Theory

L-T-P: 3-1-0
Credit: 4

No. of lectures: 48

Course Description

This course provides an in-depth exploration of spectral graph theory, focusing on the eigenvalues and eigenvectors of graph matrices and their structural, com- binatorial, and applied implications. Topics include the spectral properties of adjacency and Laplacian matrices, graph invariants, spectral inequalities, and their connections to extremal combinatorics and network science.

Course Objectives

Upon successful completion of the course, students will be able to:

CO1: Understand the spectral properties of different graph matrices and their mathematical foundations,

CO2: Analyze the relationship between eigenvalues and graph structural properties such as connectivity, expansion, and clustering,

CO3: Explore the role of spectral graph theory in extremal combinatorics and various mathematical applications,

CO4: Analyze the extremal combinatorics and various mathematical applications in spectral graph theory.

CO5: Develop research skills in spectral analysis, including problem-solving and proof techniques.

Course Outline

Module 1: Introduction to Spectral Graph Theory

Graph definitions: adjacency matrices, Laplacian matrices, incidence matrices, eigenvalues and eigenvectors of graph matrices, spectral decomposition and ap- plications, spectra of specific graphs: complete graphs, cycles, bipartite graphs,

trees, eigenvalue interlacing and its applications, spectral inequalities: Weyl's inequality, Cauchy's interlacing theorem.

Module 2: Adjacency Matrix and Its Properties

Characteristic polynomial of graphs and combinatorial interpretation, spectral radius and its implications for graph expansion, spectral gap and its role in connectivity and robustness.

Module 3: Laplacian Matrices and Their Applications

Properties of the Laplacian matrix and connectivity, normalized Laplacian and random walks on graphs, Cheeger's inequality and expansion properties, spec- tral interpretation of Markov chains, isoperimetric problems in spectral graph theory.

Module 4: Spectral Graph Invariants

Algebraic connectivity (Fiedler value), Laplacian energy and graph irregular- ity, eigenvalue bounds for graph diameter and girth, applications in extremal combinatorics.

References

1. Chung, F. R. K. – *Spectral Graph Theory*, CBMS Regional Conference Series in Mathematics, American Mathematical Society, 1997.
2. Brouwer, A. E., Haemers, W. H. – *Spectra of Graphs*, Springer, 2012.

COPO-mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	1
CO2	3	2	2	-	-	-	-	-	-	-	-	1
CO3	3	3	2	-	-	-	-	-	-	-	-	1
CO4	3	3	2	-	-	-	-	-	-	-	-	1
CO5	3	3	2	-	-	-	-	-	-	-	-	1