Islamic University of Science & Technology

Department of Mathematical Sciences

Ph.D. Course Work

Course Structure (Mathematics)

Course Type	Course Code	Course Title	Course Type	Maximum Marks			Credit Distribution			Credits
				Internal	Final	Total	L	T	P	
Core	RPE900C	Research and Publication Ethics	Core	25	25	50	2	0	0	2
	MTH901C	Research Methodology	Core	50	50	100	3	1	0	4
	MTH905C	Advanced Linear Algebra	Core	50	50	100	3	1	0	4
Research Centric	STA903C	Seminar on Recent Developments in the Area of Research	Core	Write-up-50 Presentation-30 Viva-20						2
Discipline Centric Elective Courses	MTH 906E	Advanced Time-Frequency Analysis	Elective	50	50	100	3	1	0	4
	MTH907E	Recent Advances in Spectral Graph Theory	Elective	50	50	100	3	1	0	4
	MTH908E	Special Functions and Integral Transforms	Elective	50	50	100	3	1	0	4
Total credits										**16**

Common Course for all disciplines

Course Title : Research and Publication Ethics

Course Code : RPE900C
Credits : 2
Marks : 100

UNIT 1:

Part A: Philosophy and Ethics

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

Part B: Scientific Conduct

1. Ethics with respect to science and research
2. Intellectual honest and research integrity
3. Scientific misconducts: falsification, fabrication, and plagiarism.
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data.

UNIT 2: 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 verse, types
5. Violation of publication ethics, authorship and contributor ship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

UNIT 3:

Part A: Open Access Publishing

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright and self-archivingpolicies.
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, SpringerJournal Suggested, etc.

Part B: Publication Misconduct

Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad, Use of plagiarism software like Turnitin, Urkund and other opensource software tools.

Unit 4:

Part A: Databases

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

Part B. Research Metrics

Impact Factor of journal as per journal citation report, SNIP, SJR, IPP,
Cite Score,Metrics: h-index, g index, i10 index, altmetrics

Books Recommended:

1. Indian National Science Academy (INSA) Ethics in Science and Education, research and government (2019) ISBN: 978-81939482-1-7 http://www.insaindia.res.in/pdf/Ethics_Books.pdf
2. P.Chaddah. (2018) Ethics in competitive Research , Do not get scooped; do not get plagiarized, ISBN: 978-9387480865
3. Beall, J (2012). Predatory publishers are corrupting open access, Nature ,(489 (7415), 179-179, http://doi.org/10.1038/489179a
4. Resnik, D.B(2011) What is ethics in research and why it is important , National Institute of Environmental Health Sciences , 1-10. retrieved from, http://niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
5. National Academy of Sciences. National Academy of Engineering and Institute of Medicine(2009) on being a scientist : guide to Responsible conduct in research : Third Edition. National Academies Press
6. Bird,A. (2006) Philosophy of Science. Routledge
7. MacIntyre. Alasdair (1967) A short story of Ethics. London

CORE (C) COURSES

Course Title: Research Methodology

Course Code: MTH901C
Credits: 4
Marks: 100

Unit I:

A brief history of important mathematical ideas and their evolution. Mathematical thinking, logic, statements, logical operations, quantifiers, different techniques of proofs viz. mathematical induction, deduction, proof by contradiction, Inverse and converse, contraposition, proof by construction, proof by counter examples, vocabulary and grammar of mathematical writing.

Unit II:

Permutations, Combinations, Partitions, Fibonacci numbers, block designs, partially ordered sets, lattices, Boolean algebras, axiom of choice, continuum hypothesis and Godel's incompleteness theorems

Unit III:

Overview of mathematical research, Selection of a research topic and a research problem, Literature survey of the topic and problem, Writing references and bibliography. Presentations: Importance of effective presentation, How to write good papers, models of the paper writing process, The benefits of targeting good journals, Peer review, How to respond to reviewer comments. Funding agencies, Writing a research grant proposal,

Unit IV:

What is LATEX?, Automatic styling according to Journal requirements, Cross references, Writing complex maths. The LATEX document, Typical input files, Post-processed look, The Edit/Format/Preview Process, Embedding references in the document, Bibliography management using BIBTEX, Searching Google, Mathscinet, Scopus, SCI , Impact factor, H-index, Google scholar.

Books recommended:

1. Katz Victor J., A History of Mathematics: An Introduction, 3rd edition, Addison-Wesley, 2009.
2. D. Solow , How to read and do proofs: an introduction to mathematical thought process

1. Stephen Hawking, God Created the Integers: The Mathematical Breakthroughs That Changed History
2. L. Lamport, LaTex, *A Documentation System*, 2nd ed., Addison-Wesley, 1994.

3. Frank Mittelbach, Michel Goosens, Johannes Braams, David Charlis, Chris Rowley,

The LaTex Companion, 2nd ed.(LTCT series), Addison-Wesley, 2004.

4. Nicholas J. Higham, *Handbook of Writing for the Mathematical Sciences*, 2nd ed. SIAM, 1998.

5. Donald E. Knuth, Tracy L. Larrabee, Paul M. Roberts, *Mathematical Writing*, Mathematical Association of America Washington, D.C., 1989.

6. M. K.Jain, Computational techniques and Numerical methods.

Annexure

A list of proposed assignment topics for the research scholars to improve their writing skills and their ability to commence a good literature survey

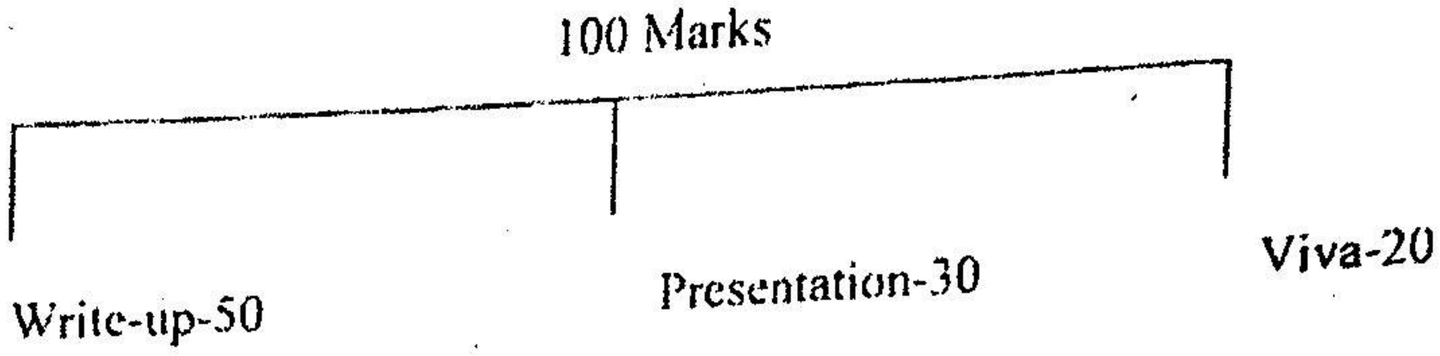
1. Assignment 1: Download and read a good quality PhD thesis in an area related to your research area. Summarize the work in 500 words.
2. Assignment 2: List the top rated journals and conferences in your chosen areas. List some well known researchers whose work in your chosen area has been well recognized as outstanding and exemplary. Also write a short note about the contribution by any two of them.
3. Assignment 3: Literature review: Shortlist 10 good quality papers in your research area. Write a report containing the list of papers with citation count, extract and tabulate the research method (in domain independent language) used by the researchers for all these papers. Identify three examples where some researcher in your area has challenged the assumptions of earlier work.
4. Assignment 4: Write a note about the main contemporary challenges for humanity. Address these questions: What research trends in your chosen area are trying to meet these challenges? How do you intend to contribute to advance these trends through your PhD research?
5. Assignment 5: In your chosen research area, list some standardized data sets for researchers that are available in public domain. Write a short note about the evolution and utility of each of these data sets OR/AND Write an essay describing the evolution of mathematical modeling in your area. Also highlight the factors that have contributed to such evolution. Cite your references. OR/AND Experiments in your research area: Summarize 5 experiments performed recently by some researchers in your area. Reflect on these summaries to write a short essay.

Course Title: Seminar on Recent Developments in the Area of Research

Course Code: MTH903C
Credits: 2
Marks: 100

Review of Recent literature:

Preparation of a comprehensive and critical review of the already published literature (recent 10 papers) in the proposed field of his/her study. The candidate will be evaluated on the basis of this review report and a seminar to be delivered at the end of the semester.



Course Title: Advanced Linear Algebra

Course Code: MTH905C
Credit : 4
Marks : 100

Unit-I

Eigen values and Eigen vectors: Special Matrices and their Eigen values, characteristic Polynomial, Elementary properties of Eigen systems, Diagonalizability by similar Transformation, functions of Diagonalizable matrices, normal matrices, nilpotent matrices, Jordan Structure, partitioning of matrices.

Unit-II

Inner Products: Inner product spaces, orthogonal vectors, Gram-Schmidt procedure, Unitary and orthogonal Matrices, orthogonal reduction, Discrete reduction, Discrete Fourier Transform, complementary subspaces.

Unit-III

Decomposition and positive Definite Matrices: Range-nullspace decomposition, orthogonal decomposition, Orthogonal projection, Perron-Frobenius Theory, Positive matrices, Minima, Maxima and saddle points, Tests for positive definiteness, singular value decomposition, stochastic matrices, Markov Chains.

Unit IV:

Norms: Vector norms, Matrix norm and Trace norm of a matrix, Location and perturbation of Eigen values, Singular values and eigenvalues, Ky Fan k-norm, Laplacian Eigen values of a Laplacian Matrix, Laplacian spectral radius, Basic upper and lower bounds interms Laplacian Eigen values,

Recommended Books:

1. Carl D. Meyer, Matrix Analysis and Applied Linear Algebra.
2. Gilbert Strang, Linear Algebra and its applications, Fourth Edition.
3. Richard A. Brualdi, DragosCvetkovic, A combinatorial Approach to Matrix Theory and Its Applications.
4. R. Horn and C. Johnson, Matrix Analysis, Cambridge University press, 1985.

5. Seymour Lipschutz and Marc Lipson, Schaum's outlines, Linear Algebra
6. R. Horn and C. Johnson, Topics in Matrix Analysis, Cambridge University Press, 1991.
7. Vinit K. Sinha, Introduction to Matrix Theory
8. Xian- Da-Zhang, Matrix Analysis and Applications.
9. R. Horn and C. Johnson, Matrix Analysis, Cambridge University press, 1985.
10. R. Horn and C. Johnson, Topics in Matrix Analysis, Cambridge University Press, 1991.

Course: Advanced Time-Frequency Analysis

Course Code: MTH 906E

Credits: 4

Marks:100

Unit-I

Fourier series, Fourier transforms, Convolution theorem, Plancherel's and Parseval's formulae, Poisson summation formula, Shannon-Whittaker sampling theorem, Heisenberg's uncertainty principle, Applications of Fourier transforms in Mathematical Statistics, Ordinary differential equations, Integral equations, and Partial differential equations.

Unit-II

Windowed Fourier transform, fundamental properties of windowed Fourier transform including convolution theorem, Moyal's principle, reconstruction formula and characterization of range, Generalized Fourier transform, Quaternion Fourier transform, fractional Fourier transform, linear canonical transform, Stockwell transform and its properties.

Unit-III

Continuous wavelet transforms in L2(R) and their fundamental properties, Examples of orthonormal wavelets and their Fourier transforms (Haar, Mexican, Meyer, Morlet), Moyal's formula, Parseval's formula, Energy preserving relation, Inversion formula, Discrete wavelet transform, Discrete Daubechies transformation.

Unit-IV

Motivation, definition and examples of Multiresolution Analysis (MRA) with special reference to Haar MRA and Shannon's MRA, Properties and characterizations of scaling functions, Construction of orthonormal wavelet bases in L2(R), Characterization of orthonormal wavelets via Fourier transforms, Dimension function. nonuniform MRA, Biorthogonal scaling functions and wavelets, Wavelet packets.

Recommended Books:

5. S. T. Ali, J. P. Antoine and J. P. Gazeau (2014): *Coherent States, Wavelets, and Their Generalizations*, Springer, New York.
6. M.W. Wong (2002): *Wavelet Transforms and Localization Operators*, Birkhauser, Boston.
7. L. Debnath and Firdous A. Shah (2015): *Wavelet Transforms and Their Applications*, Birkhauser, New York.
8. D. K. Ruch and P. J. Van Fleet (2009): *Wavelet Theory*, John Wiley.
9. P. Nickolas, *Wavelets (2017): A Students Guide*, Cambridge University Press.
10. G. Kutyniok and D. Labate, *Shearlets (2012): Multiscale Analysis for Multivariate Data*, Birkhauser-Springer, Basel.

Course Title: Recent advances in Spectral Graph Theory

Course Code: MTH907E
Credit: 4
Marks: 100

Unit I:
Types of Graphs, Isomorphism, Subgraphs, Walk, Path and Cycle, Operation on graphs, Degree Sequence and Degree set of a graph, Eulerian and Hamiltonian Graphs, Eulers Theorem, Konigsberg Bridge Problem, Trees, Different Characterizations, connectivity parameters, Whitney Theorem, Planarity, Eulers Theorem on number of regions.

Unit II:

Adjacency matrix, Laplacian matrix, skew Laplacian matrix, characteristic equation of a matrix associated with a graph, Eigen values of adjacency matrix, energy of a graph, Co-spectral graphs, Spectral radius of a graph, pigeonhole principle.

Unit III:
Eigen values of Graphs, Characteristic Polynomial, Sachs Theorem, Pairing theorem, walks and diameter, Co-spectral graphs, Eigen values of regular graphs complement of regular graphs and line graphs of regular graphs. Stable matrices and inertia, Singular value inequalities, matrix equations and the Kronecker product, Schur product theorem and its generizations.

Unit IV:
Variation characterizations of Eigen values of Hermitian matrix, Spectral radius of a graph, Basic upper and lower bounds, other matrices related to graphs, Energy of Graphs, Basic upper and lower bounds, Coulson integral formula, Conjectures on Eigen values and energy of a graph.

Recommended Books:

1. R. B. Bapat, Graphs and Matrices, Springer.
2. G. Chartrand, Graphs and Digraphs, CRC Press.
3. D. Cvetkovic, M. Doob, H. Sachs, Spectra of Graphs, Theory and Applications, Academic Press.
4. C. Godsil, Gordon Royle, Algebraic Graph Theory, Springer.
5. Richard A. Brualdi, DragosCvetkovic, A combinatorial Approach to Matrix Theory and Its Applications.
6. X. Li, Y. Shi, I. Gutman, Graph Energy, Springer.
7. S. Pirzada, An Introduction to Graph theory, Universities Press, OrientBlackSwan, 2012.
8. D. B. West, Introduction to Graph Theory, Prentice Hall.
9. Lowell W. Beineke, Robin J. Wilson, Topics in Algebraic Graph Theory
10. Jason J. Molitierno, Applications of Combinatorial Matrix Theory to Laplacian Matrices of Graphs.

Course: Special Functions and Integral Transforms

Course Code: MTH19081E

Credits: 4

Marks: 100

Unit-I

Hypergeometric functions, Definition of the basic hypergeometric series and function, properties of hypergeometric functions, Integral formula for hypergeometric series, Heine's transformation formula. Summation, transformation and expansion formulas. Basic contour integrals. Applications to orthogonal polynomials.

Unit-II

Jacobi triple product identity, theta functions, and elliptic numbers, elliptic and theta hypergeometric series, additive notions and modular series, Fourier transforms and its properties, Hankel and Millen transform and their properties.

Unit-III

Legendre's differential equation and its series solution, generating functions of Legendre's polynomials $P_n(x)$, orthogonality, Laplace's first and second integral for $P_n(x)$, Rodrigues formula, Recurrence relations. Bessel's equation and its solution, Bessel function of ist kind, generating function for $J_n(x)$, Recurrence relation, integral representations for $J_n(x)$, addition formula for Bessel functions, Orthogonality.

Unit-IV

q-shifted factorial, identities involving q-shifted factorial, q-gamma and q-binomial functions and their coefficients, q-integral.

Recommended Books:

1. E. D. Rainville (1960): *Special Functions*, Macmillan and Co., New York.
2. V. Kac and P. Cheung (2002): *Quantum Calculus*, Springer, New York.
3. W. N. Bailey (1964): *Generalized Hypergeometric Series*, University Press.
4. G. Gasper and M. Rahman (2004): *Basic Hypergeometric Series*, Cambridge University Press.
5. B. C. Berndt (1985): *Ramanujan's Notebooks*, Part I, Springer, New York.
6. B. C. Berndt (1989): *Ramanujan's Notebooks*, Part II, Springer, New York.

Research Papers:

1. L. J. Slater (1955): Some basic hypergeometric transforms, *J. London Math. Soc.* 30, 404-413
2. H. Exton (1977): The basic double hypergeometric transforms, *Indian J. Math.* 19,