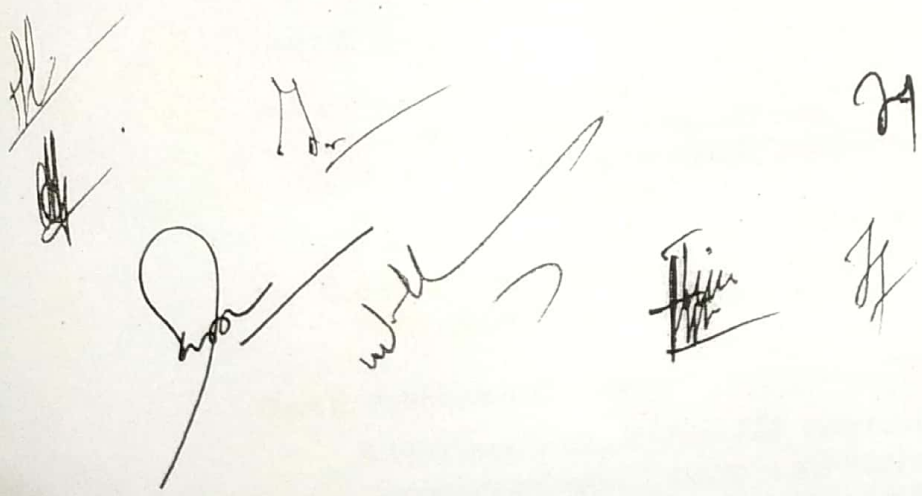


# MATHEMATICAL SCIENCES

## MATHEMATICS

### Course Structure

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
	MTH902C	Advanced Wavelet Theory	Core	50	50	100	3	1	0	4
Research Centric	MTH903C	Seminar on Recent Developments in the Area of Research	Core	Write-up-50 Presentation-30 Viva-20		100				2
Discipline Centric Elective	MTH904E	Time-Frequency Analysis	Elective	25	25	50	2	0	0	4
	MTH905E		Elective							
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 versa, 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-archiving policies.
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.

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#### 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](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.(TTCT 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: Advanced Wavelet Theory

Course Code: MTH902 C

Credits: 4

Marks: 100

Unit-I

Continuous wavelet transforms in  $L^2(\mathbb{R})$  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-II

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  $L^2(\mathbb{R})$ , Characterization of orthonormal wavelets via Fourier transforms, Dimension function. nonuniform MRA, Biorthogonal scaling functions and wavelets, Wavelet packets.

Unit-III

Linear canonical wavelet transform, and Fractional wavelet transform and associated properties, Continuous wavelet transforms on locally compact abelian groups and their basic properties, Derivation of admissibility condition, Square integrable representations, wavelets on affine Weyl-Heisenberg group.

Unit-IV

Two-dimensional continuous wavelet transform, Basic properties of 2D-wavelet transform, Examples of isotropic and non-istropic wavelets, Polar wavelet transform and its properties, Continuous shearlet transforms, Examples of shearlets, Continuous wavelet transforms in  $L^2(\mathbb{R}^n)$ , Rayleigh's theorem, inversion formula and characterization of range of continuous wavelet transform in  $L^2(\mathbb{R}^n)$ , Two-dimensional quaternion wavelet transform, Quaternion Fractional wavelet transform, Quaternion linear canonical wavelet transform.

Recommended Books:

1. S. T. Ali, J. P. Antoine and J. P. Gazeau, *Coherent States, Wavelets, and Their Generalizations*, Springer, New York, 2014.
2. M.W. Wong, *Wavelet Transforms and Localization Operators*, Birkhauser, Boston, 2002.

3. L. Debnath and Firdous A. Shah, *Lecture Notes on Wavelet Transforms*, Birkhauser, Boston, 2017.
4. L. Debnath and Firdous A. Shah, *Wavelet Transforms and Their Applications*, Birkhauser, New York, 2015.
5. D. K. Ruch and P. J. Van Fleet, *Wavelet Theory*, John Wiley, 2009.
6. P. Nickolas, *Wavelets: A Students Guide*, Cambridge University Press, 2017.
7. G. Kutyniok and D. Labate, *Shearlets, Multiscale Analysis for Multivariate Data*, Birkhauser-Springer, Basel, 2012

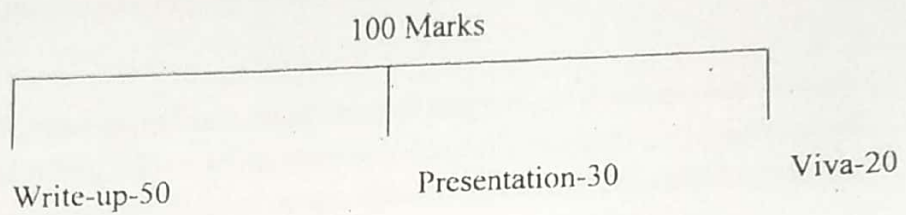
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Course Title: Seminar on Recent Developments in the Area of Research

Course Code: S XXXX 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.



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## Discipline Centric Elective (E) Courses

Course Title: Time-Frequency Analysis

Course Code: MTH904E

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, Quaternion Fourier transform its types, properties, and associated Heisenberg's uncertainty principle.

### Unit-III

Fractional Fourier transform, inversion, Plancherel's and Parseval's formulas of the fractional Fourier transform, discrete fractional Fourier transform, Polar Fourier transform, Linear canonical transform, windowed linear canonical transform, basic properties of windowed linear canonical transform, Poisson summation formula for the windowed linear canonical transform. Stockwell transform and its properties.

### Unit-IV

Some basic facts about Frames, Frame bounds and Frame algorithms, Bases and Biorthogonal systems in  $H$ , The Gram Matrix, Riesz bases, Frames in Hilbert spaces, Riesz sequences, Conditions for a Frame being a Riesz basis.

### Recommended Books:

1. T. Butz, *Fourier Transformations for Pedestrians*, Springer, 2016.
2. L. Debnath and Firdous A. Shah, *Wavelet Transforms and Their Applications*, Birkhauser, 2015.
3. L. Debnath and P. Minkusinski, *Introduction to Hilbert Spaces with Applications*, Academic Press, New York, 2003.
4. K. B. Howell, *Principles of Fourier Analysis*, Chapman & Hall/ CRC, Press, 2001.
5. J.J. Healy, M.A. Kutay, Ozaktas and J.T. Sheridan, *Linear Canonical Transforms*, New York, Springer, 2016.
6. M. Pinsky, *Introduction to Fourier Analysis and Wavelets*, Brooks/Cole Publishing, 2002.
7. O.Christensen, *An introduction to Frames and Riesz Bases*, Birkhauser,