M. Phil. (Mathematics) Part Time

About the programme
The duration of part-time M.Phil. Programme two years with 4 semesters. The course work includes two core papers during the first semester and one Elective during the second semester. The key focus of the programme would be to provide an in-depth understanding of various theoretical and scientific contributions that have both practical significance and rigorous, elegant research skills. It covers advanced material in both theoretical and applied areas as well as instilling the elements of research practice. The programme combines lectures, criticism classes, seminars and research work in various combinations tailored to the individual students. M.Phil. scholars in Mathematics perform individual research in any of the areas under the direct supervision of an academic expert and submit a dissertation at the end of the course.

Academic structure of the programme
The proposed programme will have a flexible academic structure and pedagogic approach. The need of students in different fields of Mathematics will be catered by offering a range of relevant electives.

Pedagogic approaches
Some of the key pedagogic approaches would involve the following:

- Academic lectures
- Extramural Lecture Series
- Group discussions and debates
- Visual Presentations
- Literature review
- Preparation and presentation of research articles in conferences and seminars
- E-Learning modules

Curriculum and Credit Distribution

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<th>Semester I</th>
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<td>Foundations of Modern Mathematics</td>
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LIST OF ELECTIVES

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<td>18MAT737</td>
<td>Theory of Knots and Braids</td>
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**Detailed Syllabus for M.Phil. in Mathematics**

18MAT701 Research Methodology 3-1-0-4

This course comprises of topics of research methodology in general, methodology of research in Mathematics, methodology of teaching Higher Mathematics, modern tools for teaching and research and Ethics in research.

1.1 Research

1.1.1. General introduction to research methodology

Meaning and objective of scientific research, Types and significance of research, Methods of scientific research, Research process and criteria for good research, Stages of research.

Reference: Research Methodology, by C.R. Kothari et al.

1.1.2. Methodology of Research in Mathematics

Identifying a broad area. Collecting materials for deep understanding of fundamentals as well as recent findings. Identifying an area for in-depth study. Collecting and reading as many documents as possible. Studying recent research findings and trying solutions independently. Fixing exact problem/concept or research.

1.1.3. Information Resources and Publication

This section deals with the sources of information. Classical sources, Modern sources, availability of online resources (free and subscribed), Accessibility of Journals and other print documents. Needs, ways and means of publication of research findings.

1.2 Teaching and learning

1.2.1. Modern and classical methods and techniques of teaching.


1.2.2. Innovative Methods of Teaching and Learning.

* Graphing and computation (KMPlot, Geogebra, Scilab, SageMath, GGAP and R)
* Document preparation (LaTeX)
* Presentation (Beamer)

1.3 Ethics in research
1.3.1. Piracy and Plagiarism.
1.3.2. Morality and ethics.
1.3.3. Rules and regulations – IPR.

18MAT702 Foundations of Modern Mathematics 3-1-0-4

This course aims to provide a sound philosophical foundation of Modern Mathematics. It would also provide an understanding of the inter-relation between various branches of Mathematics. Applications of Mathematics in various fields including modern technology also to be discussed.

2.1. History of Mathematics

Reference to contributions of Indian Mathematicians:
Aryabhata (476–550 AD), Varahamihira (505–587 AD), Yativṛṣabha (6 C-AD), Brahmagupta (598–670 AD), Bhaskara I (600–680 AD) Shridhara (650–850 AD), Mahavira (9 C-AD), Pavuluri Mallana (11 C-AD), Hemachandra (1087–1172 AD), Bhaskara II (1114–1185 AD), Narayana Pandit (1340–1400 AD), Sangamagrama Madhava (1340–1425 AD), Parameshvara, (1360–1455 AD), Nilakantha Somayaji, (1444–1545 AD), Raghunatha Siromani, (1475–1550 AD), Mahendra Suri (14 C-AD), Shankara Vajir (c. 1530), Jyeshtadeva, (1500–1610), Achyuta Pisharati (1550–1621), Srinivasa Ramanujan, Harish Chandra, R.C.Bose, Sirkhande, P.C.Mahalanobis.

Ancient Indian systems of numbers - KATAPAYDI, Bhuta Sanghtya

Reference: Ancient Indian Mathematics: an overview, S.G. Dani, School of Mathematics, TIFR, Bombay

2.2. Algebra

Galois theory


2.3. Topology

Review of basic topology, Homotopy


2.4. Modern Analysis

Theory of distributions and Fourier Transform


2.5. Measure theory

Review of basic measure theory, Radon-Nikodym theorem.

ELECTIVES

18MAT731 ADVANCED GRAPH THEORY AND ITS APPLICATIONS 3-1-0-4

Unit 1:
Introduction: Definition of graph-degree of vertex - Regular graphs - Connected graph, complete graphs - Bipartite graph - Euler graph necessary and sufficient conditions for Euler graph-Hamiltonian graph and its properties - Connectivity, vertex connectivity, edge connectivity. Trees - properties of Trees-spanning tree

Unit 2:
Domination theory - Definition of dominating sets in graphs- Domination number- bounds in terms of degree, diameter and girth- product graphs and Vizing’ s conjecture

Unit 3:

Unit 4:
Four Standard Graph Products - Cartesian Product - Strong Product - Direct Product - Lexicographic Product – distance formula

Unit 5:
Three Fundamental Products – Commutativity property, Associativity property - Projections and Layers

References:

18MAT733 CODING THEORY AND CRYPTOGRAPHY 3-1-0-4

Unit 1
Introduction to linear codes and error correcting codes. Encoding and decoding of a linear code,

Unit 2
Dual codes, Hamming codes and perfect codes.

Unit 3
Cyclic codes. Codes with Latin Squares, Introduction to BCH codes.

Unit 4
Classical ciphers: Cryptanalysis of classical ciphers, Probability theory, Perfect security.
Block ciphers: DES, AES, Block cipher modes of operation.

Unit 5
Private-key encryption: Chosen plaintext attacks, Randomised encryption, Pseudo randomness, Chosen ciphertext attacks.

REFERENCES:

18MAT734 HOMOLOGICAL ALGEBRA 3 - 1 - 0 - 4

Unit 1: Simplicial Complexes and Homology Groups
Definition and elementary properties-Slices, Simplicial complexes and Simplicial maps, homology Groups, Zero-dimensional Homology, The Homology of a cone, Homomorphism induced by Simpicial Maps, Chain Complexes and Acyclic Carriers.

Unit 2: Relative Homology and Eilenberg-Steenrod Axioms
Relative Homology, the Exact Homology Sequence, the Zig-zag Lemma, Mayer-Vietoris Sequences, the Eilenberg-Steenrod Axioms, the Axioms for Simplicial Theory. Categories and functors.

Unit 3: Singular Homology
The Singular Homology Groups, the Axioms for Singular Theory, Excision in Singular Homology, Mayer-Vietoris Sequences, the Isomorphism between Simplical and Singular Homology, More on Quotient Spaces, CW Complexes and their Homology.

Unit 4: Cohomology and Homological Algebra
The Hom functor, Simplicial Cohomology Groups, Relative Cohomology, Cohomology theory, The Ext Functor, The Universal Coefficient Theorem for Cohomology, Torsion Products, The Universal Coefficient Theorem for Homology, Kunneth Theorems (for cohomology and homology proofs can be omitted)

Unit 5: Applications
Local Homology Groups and Manifolds, the Jordan Curve Theorem, Projective spaces and Lens Spaces, The Cohomology Ring of a Product Space

REFERENCES:

18MAT735 STOCHASTIC PROCESSES 3-1- 0 - 4

Unit 1
Introduction to probability theory and random process

Unit 2
Unit 3
Some Queuing Models (M/G/1, G/M/1), Random Walk: Continuous Time Markov Chains : Birth process, Birth & Death processes, Differential Equations of Birth & Death Processes, Absorption

Unit 4

Unit 5
Martingales : Supermartingales and Submartingales, Optional Sampling Theorem, Martingale conveyance Theorems

REFERENCES

18MAT736 THEORY OF FLUID DYNAMICS 3 - 1 - 0 - 4

Unit 1 Basic Concepts and Properties
Fluid – definition, distinction between solid and fluid - Units and dimensions – Properties of fluids – density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillary and surface tension – Fluid statics: concept of fluid static pressure, absolute and gauge pressures – pressure measurements by manometers and pressure gauges.

Unit 2 Fluid Kinematics
Fluid Kinematics - Flow visualization - lines of flow - types of flow - velocity field and acceleration - continuity equation (one and three dimensional differential forms)- Equation of streamline - stream function - velocity potential function - circulation - flow net.

Unit 3 Fluid Dynamics
Fluid dynamics - equations of motion - Euler's equation along a streamline - Bernoulli's equation – applications - Venturi meter, Orifice meter, Pitot tube - dimensional analysis - Buckingham's theorem - applications - similarity laws and models.

Unit 4 Incompressible Fluid Flow
Viscous flow - Navier - Stroke's equation (Statement only) - Shear stress, pressure gradient relationship - laminar flow between parallel plates - Laminar flow through circular tubes (Hagen poiseulle's).

Unit 5 Flow Through Pipes
Hydraulic and energy gradient - flow through pipes - Darcy-weisback's equation - pipe roughness - friction factor - Moody's diagram - minor losses - flow through pipes in series and in parallel - power transmission - Boundary layer flows, boundary layer thickness, boundary layer separation - drag and lift coefficients.

REFERENCES:

18MAT737 THEORY OF KNOTS AND BRAIDS 3 - 1 - 0 - 4

Unit 1 **Knots, Knot arithmetic and Invariants:**

Knots- Definition, Simple examples, Elementary properties, Polygonal links and Reidemeister moves Knot arithmetics and Seifert surfaces; Knots in Surfaces- Torus Knots, The linking coefficient, The Arf invariant and The colouring invariant.

Unit 2 **Fundamental group, Quandle and Conway’s algebra**

Examples of unknotting, Fundamental group, Calculating knot groups, Quandle- Geometric description of the quandle, Algebraic description of the quandle, Completeness of the quandle, Special realisations, Conway algebra and polynomials, Realisations of the Conway algebra, Matrix representation.

Unit 3: **Jones polynomial and Khovanov’s polynomial**

Kauffman’s bracket, Jones’ polynomial and skein relations, Kauffman’s two–variable polynomial, Jones’ polynomial. Khovanov’s complex, Simplest properties, Tait’s first conjecture and Kauffman–Murasugi’s theorem, Classification of alternating links, The third Tait conjecture, A knot table, Khovanov’s polynomial, The two phenomenological conjectures.

Unit 4: **Braids, links and representations**

Definitions of the braid group- Geometrical definition, Topological definition, Algebro– geometrical definition and Algebraic definition; Equivalence of the four definitions, The stable braid group, Pure raids, Links as braid closures, Braids and the Jones polynomial; Representations of the braid groups- The Burau representation, The Krammer–Bigelow representation, Krammer’s explicit formulae, Bigelow’s onstruction, Alexander’s theorem, Spherical and cylindrical braids; Vogel’s algorithm.

Unit 5: **Vassiliev’s invariants and the Chord diagram algebra**

Vassiliev’s invariants-Definition and Basic notions, Singular knots, Invariants of orders zero and one, Examples of higher–order invariants, Conway polynomial coefficients, Other polynomials and Vassiliev’s invariants, An example of an infinite-order invariant, The Chord diagram algebra - Chord diagram algebra- Basic structures, Bi algebra structure, The four colour theorem.

**REFERENCES:**