Pre-Ph.D. Course Work in Mathematics

PROGRAMME OUTCOMES:

Ph. D Students will be able to

PO-1: This course improves the standards of research.

PO-2: After completing Ph.D. program students are gaining through research knowledge in pure and applied mathematics.

PO-3: The mathematical curriculum offers a number of practical exposures which equips the students to face the research challenges in Mathematics.

PO-4: The objective of the course is to introduce students to research skills and specialize in a relevant to their research interests under close supervision.

PO-5: To give students the opportunity to acquire or develop skills and expertise a comprehensive understanding of techniques and a thorough knowledge of the literature which applicable to their own research.

PO-6: To demonstrate originality in the application of knowledge together with a practical understanding of how research and enquiry are used to create and interpret knowledge in their field.

PO-7: Demonstrated some self-direction and originality in tackling and solving problems, and acted autonomously in the planning and implementation of research; and produced a dissertation for examination.

PO-8: Able to apply advanced theoretical and/or experimental methods, including the use of different methods in mathematics and simulations.

PO-9: Each student is required to make a seminar presentation on any chosen topic connected with the field of specialization. Preparation and presentation of a seminar is intended to investigate an in-depth review of literature and develop confidence to present the material by the student.

PROGRAMME SPECIFIC OUTCOMES:

PSO-1: Students will be able to publish research articles in reputed journals.

PSO-2: This course introduces the students to the new concept of mathematics and their application in real life situations.

PSO-3: This course equips the students to become effective teachers and researchers in Mathematics, to contribute to the needs of the society, by providing an environment of learning and knowledge creation through academic rigor and innovation.

PSO-4: Develops to independently asses and evaluate research methods and results.

PSO-5: Develops the ability to critically evaluate his current research topic, research techniques and methodologies.

GURU GHASIDAS VISHWAVIDYALAYA
KONI, BILASPUR, (C. G.)
DEPARTMENT OF MATHEMATICS
Pre-Ph.D. Course Work in Mathematics
(COURSE STRUCTURE & SYLLABUS)

COURSE TYPE	COURSE CODE	COURSE NAME	Credit/ Hours (L-T-P)	TOTAL MARKS
COMPULSORY PAPER	MaPhD01	RESEARCH METHODOLOGY	4(3-1-0)	100
OPTIONAL PAPERS **(ANY TWO)**	MaPhD02	INTRODUCTORY FUZZY GROUP THEORY	4(3-1-0)	100
	MaPhD03	APPLIED FUNCTIONAL ANALYSIS	4(3-1-0)	100
	MaPhD04	CRYPTOGRAPHY	4(3-1-0)	100
	MaPhD05	DYNAMICAL SYSTEM	4(3-1-0)	100
	MaPhD06	GEOMETRY OF FINSLER SPACE	4(3-1-0)	100
	MaPhD07	STRUCTURES ON MANIFOLDS	4(3-1-0)	100
	MaPhD08	FIXED POINT THEORY AND APPLICATIONS	4(3-1-0)	100
	MaPhD09	MECHANICS OF SOLIDS AND WAVE PROPAGATION	4(3-1-0)	100
	MaPhD10	ADVANCED NUMERICAL ANALYSIS	4(3-1-0)	100
	MaPhD11	ITERATIVE METHODS FOR SOLVING NON-LINEAR EQUATIONS	4(3-1-0)	100
	MaPhD12	FRACTIONAL CALCULUS	4(3-1-0)	100
TOTAL CREDITS : 12				

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD01	3	1	0	4 HOURS	100	4

Paper Code: MaPhD01

RESEARCH METHODOLOGY

Course Objectives: The main concern of Research Methodology is to –

1) To provide an introduction to the foundations of research, including its meaning, objectives, motivation, and utility.
2) To familiarize students with the concepts of theory, empiricism, deductive and inductive theory, and their relevance to research.
3) To teach students the characteristics of the scientific method and the importance of understanding the language of research, including concepts such as construct, definition, variable, and the research process.
4) To provide an understanding of research design, including its concept and importance in research, the features of a good research design, and different types of research designs such as exploratory, descriptive, and experimental designs.
5) To familiarize students with the basic concepts of independent and dependent variables in experimental design, and introduce them to some software that can aid in research design.

Course Contents:

Philosophy and Ethics: Introduction to philosophy, definition, nature and scope, concept, branches, Ethics, definitions, moral philosophy, nature of moral judgments and reactions.

Scientific conduct: Ethics with respect to science and research, Intellectual honesty and research integrity, scientific misconducts Falsification, Fabrication and Plagiarism (FFP), redundant publications, duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data.

Publication Ethics: Definition, introduction and importance, Best Practices/standards setting initiative and guideline, COPE, WAME, etc. Conflicts of interest, Publication misconduct, definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

MATLAB: Basics of Mathematical calculations such as Integration, Solving Matrices, Drawing Graphs, etc.

Latex: Basics of Latex such as typing a research paper, Insertion of Table, Graphs, Pictures, etc.

Wring a review of at least 01 research paper suggested by supervisor (to his student who is allotted as a Pre-PhD Course Work student by the DRC as per university guidelines).

Course Outcomes: This course will enable the students to -

1) Develop an understanding of the philosophical and ethical aspects of research and the importance of research integrity.
2) Demonstrate knowledge of scientific conduct, including ethics in science and research, intellectual honesty, and research integrity. Identify scientific misconduct, including falsification, fabrication, plagiarism, redundant and duplicate publications, and selective reporting.
3) Understand publication ethics, including the importance of best practices and standards, identification of publication misconduct, and the impact of conflicts of interest on research.
4) Acquire proficiency in using MATLAB for mathematical calculations such as integration, solving matrices, drawing graphs, and LaTeX for typing research papers, inserting tables, graphs, pictures, etc.
5) Develop critical thinking and problem-solving skills in conducting research, including the ability to identify research gaps and formulate research questions, design research studies, and Analyze and interpret data.

Overall, the course aims to equip students with the knowledge, skills, and attitudes necessary to conduct research ethically and with scientific rigor.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2		1		2			2	1		2		
CO2	3	2		1		2			2	1		2		
CO3	3	2		1		2			2	1		2		
CO4	3	2		1		1			2	1		2		
CO5	3	2		1		1			2	1		2		

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD02	3	1	0	4 HOURS	100	4

Paper Code: MaPhD02

INTRODUCTORY FUZZY GROUP THEORY

Course Objectives: The main concern of this course is to –

1) To learn to deal with uncertainty (of Fuzzy nature) and understand the scope of the subject.
2) To learn basic operations on Fuzzy sets and to understand the flexibility of various operations.
3) To understand the possibility theory and compare it with probability theory.
4) To understand the Fuzzy logic, implication rules, Fuzzification and Defuzzification methods.
5) To understand the application of Fuzzy logic in decision making under Fuzzy environment.

Course Contents:

Fuzzy Subsets, Fuzzy Subgroups, Normal Fuzzy Subgroups, Conjugate Fuzzy Subgroups Normalizer of a Fuzzy Subgroup, Left and Right Cosets of a Fuzzy Subgroup, Quotient Group of a Crisp Group relative to a Normal Fuzzy Subgroups Quotient Fuzzy Subgroup, Normal Fuzzy Subgroup of a Fuzzy Subgroup Homomorphism and Isomorphism of Fuzzy Subgroups, Fuzzy Order relative to Fuzzy Subgroup, Fuzzy order of an element of a Group, Fuzzy Order in a Cyclic Group.

Index of Fuzzy Subgroup, Fuzzy Characteristic Subgroup, Conjugate Fuzzy Subgroups, Fuzzy Cayley's Theorem and Fuzzy Lagrange's Theorem, Solvable Fuzzy Subgroup, Fuzzy Order of a Fuzzy Subgroup.

Normalizer of a Fuzzy Subset, Commutative Fuzzy Subgroup, Ascending Central Series of a Fuzzy Subgroup, Nilpotent Fuzzy Subgroups, Commutator of fuzzy Subsets, Descending Central Chain of a Fuzzy Subgroup, Central Chain of a fuzzy Subgroup, Descending Central Series of a fuzzy Subgroup, Derived Chain of a Fuzzy Subgroup, Solvable Fuzzy Subgroups, Solvable series for a Fuzzy Subgroup.

Reference Book:

1. Fuzzy Group Theory by J. N. Mordeson, K. R. Bhutani, A Rosenfield, Springer Publications.

Course Outcomes: After completion of this course a student is supposed to know:

1) Learn to deal with real world uncertainties especially of the fuzzy nature and use it as mathematical tool available for cutting edge research in the area of his/her choice.
2) Basics of fuzzy sets and the significance of application of fuzzy sets.
3) Use of fuzzy logic for decision making under real world scenario which is mostly fuzzy.

4) A student is supposed to understand the application as Fuzzy measures evidence theory, Possibility theory and probability theory.
5) Basics of fuzzy controller, idea of fuzzification and defuzzification.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	2	1	2	1	2	3	1	1	3	2	2	2	2
CO2	2	1	2	1	2	2	2	1	2	2	3	2	3	2
CO3	2	2	1	2	2	3	2	2	2	1	3	3	2	2
CO4														
CO5														

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD03	3	1	0	4 HOURS	100	4

Paper Code: MaPhD03

APPLIED FUNCTIONAL ANALYSIS

Course Objectives: The main concern of this course is to –

1) The aim of this course is to put forward the most of the concepts from Real Analysis, Algebra, linear algebra, and functional analysis. as a foundation of applied functional analysis.
2) Need to know the inner products and its geometrical properties.
3) By using various examples to understand inner products, Hilbert spaces, product of Hilbert spaces, etc. Various types of operators and their applications in convex programming.
4) Few fundamental theorems of Hahn Banach Theorem, Weak compactness theorem, Reisz Representation theorems to be for better understanding at the advance level.
5) Motivate to know the applications in the area of Differential Equations, Integral Equations, Game Theory, etc.

Course Contents:

Open Mapping Theorem, Factor Spaces, Duality, Orthogonality, Applications of Open Mapping Theorem.

The Spectrum: The Gelfand-Mazur Theorem, the Gelfand Transform, C*-Algebras.

Compact and Fredholm Operators: Compact Operators, Fredholm Operators and the Index, Spectral Theorem for Compact Operators, Applications to Integral Equations.

Reference Book:

1. Serg Lang: Real and Functional Analysis, Third Edition, Springer.

Course Outcomes: After completion of this course a student is supposed to know:

1) After this course student may understand the basic properties of Convex Programming and fundamental result of Game Theory.
2) Might understand the applicability of various branches of mathematics such as Differential equations, Integral equations, Game Theory, etc.
3) Also, they can learn the applications of linear operators and their applications.
4) They may understand how to prove some theorems under weaker conditions.
5) This course will be helpful for them in joining research in Nonlinear Functional Analysis.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	2	2	1	2	1	2	2	2	1	2	2
CO2	2	1	2	3	2	1	2	2	2	2	1	2	3	2
CO3	2	2	2	2	3	1	1	1	1	2	2	2	2	3
CO4														
CO5														

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD04	3	1	0	4 HOURS	100	4

Paper Code: MaPhD04

CRYPTOGRAPHY

Course Objective: A course on cryptography aims to introduce students to:

1) Introduce students to the basic concepts and techniques used in cryptography, including encryption, decryption, key management, and digital signatures. This includes an overview of classic and modern cryptographic algorithms and their properties.
2) Analyze cryptographic protocols for their security and privacy properties. This includes topics such as formal verification, threat modelling, and security testing.
3) Implement cryptographic algorithms using programming languages such as C++ and Python. This includes topics such as key generation, encryption, decryption, and digital signatures.
4) The applications of cryptography in various fields such as computer networks, e-commerce, and secure messaging, this includes an overview of various standard cryptographic protocols.
5) Understanding of the challenges and issues faced by real-world cryptographic systems, such as side-channel attacks, timing attacks, and implementation flaws. This includes discussions on recent security breaches and case studies of successful and unsuccessful cryptographic implementations.

Course Contents:

Foundations of Cryptography: History of Cryptography.

Encryption: Encryption system, Symmetric and Asymmetric Cryptosystems, Cryptanalysis, Alphabets and Words, Permutations, Block Ciphers, Multiple Encryption, The use of Block Ciphers, Stream Ciphers, The Affine Ciphers, Matrices and Linear Maps, Affine Linear Block Ciphers, Vigenere, Hill and Permutation Ciphers, Cryptanalysis of Affine Linear Block ciphers, Secure Cryptosystems.

Probability and Perfect Secrecy: Probability, Conditional Probability, Birthday Paradox, Perfect Secrecy, Vernam One-Time Pad, Random Numbers, Pseudorandom Numbers.

DES: Feistel Ciphers, DES Algorithm, Security of DES.
AES: Notation, Cipher, Key Expansion, InvCipher.

Prime Number Generation: Trial Division, Fermat Test, Carmichael Numbers, Miller-Rabin Test, Random Primes.
Public-Key Encryption: Idea, Security, RSA Cryptosystem, Rabin Encryption, Diffie-Hellman Key Exchange, ElGamal Encryption.

Reference Book:

1. Johannes A Buchmann, ***Introduction to Cryptography***, Springer International 2nd Edition (ISBN: 81-8128-232-9).

.**Course Outcomes:** Students undergoing this course are expected to:

1) Gain knowledge of modern cryptographic algorithms, including symmetric-key and public-key cryptography, as well as their strengths and weaknesses.
2) Understand the basic cryptographic concepts of confidentiality, integrity, authenticity, and non-repudiation, and how these concepts relate to cryptographic algorithms and protocols.
3) Learn how to analyze the security of cryptographic systems, including the identification of vulnerabilities and attacks, and the selection of appropriate cryptographic algorithms and protocols to mitigate risks.
4) Develop critical thinking and problem-solving skills through practical exercises and assignments that require the application of cryptographic concepts and techniques.
5) Develop effective communication skills through written and oral presentations of technical material related to cryptography.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	2	1	1	2	1	2	2	2	2	3
CO2	3	2	2	2	2	2	1	2	2	2	2	2	2	3
CO3	3	2	2	3	2	2	1	2	2	2	2	3	2	2
CO4	3	2	2	3	2	3	1	2	3	2	3	2	2	3
CO5	3	2	3	3	3	2	2	2	3	3	3	3	2	3

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD05	3	1	0	4 HOURS	100	4

Paper Code: MaPhD05

DYNAMICAL SYSTEM

Course Objective: A course on Dynamical System aims to introduce students to:

1) The course aims to introduce the main features of dynamical systems, particularly as they arise from systems of ordinary differential equations as models in applied mathematics.
2) The topics presented will include phase space, fixed points and stability analysis, bifurcations, Hamiltonian systems, and dissipative systems.
3) To understand Fractals and its applications in day-day-life.
4) Discrete dynamical systems will also be discussed briefly, leading to the idea of a 'chaotic' dynamical system.
5) To understand Chaotic Attractor's with examples.

Course Contents:

One Dimensional Maps: One-Dimensional Maps, Cobweb Plot: Graphical Representation of an Orbit, Stability of Fixed Points, Periodic Points, The Family of Logistic Maps, The Logistic Map $G(x) = 4x(1 – x)$, sensitive Dependence on Initial Conditions.

Two Dimensional Maps: Mathematical Models, Sinks-Sources and Saddles, Linear Maps, Coordinate Changes, Nonlinear Maps and the Jacobian Matrix, Stable and Unstable Manifolds, Matrix Times Circle Equal Ellipse.

Chaos: Lyapunov Exponents, Chaotic Orbits, Congjugacy and the Logistic Map, Transition Graphs and Fixed Points, Basins of Attaction.
Fractals: Cantor Sets, Probabilistic Constructions of Fractals, Fractals from Deterministic Systems, Fractal Basin Boundaries, Fractal Dimension, Computing the Box-Counting Dimension, Correlation Dimension.

Chaos in Two Dimensional Maps: Lyapunov Exponents, Numerical Calculation of Lyapunov Exponents, Lyapunov Dimension, A two-Dimensional Fixed Point Theorem, Markov Partitions, The Horeseshoe Map.

Chaotic Attactors: Forward limit sets, Chaotic Attactors, Chaotic Attactors of Expanding Inerval Maps, Measure, Natural Measure, and Invariant Measure for One-Dimensional Maps.

Reference Book:

1. Kathleen T. Alligood, Tim D. Sauer and James A. Yorke, ***Chaos: An introduction to dynamical systems***, Springer International Edition (ISBN: 978-81-8128-408-2).

Course Outcomes:

1) Students can understand after the course describes the main features of dynamical systems and their realisation as systems of ordinary differential equations.
2) Identify fixed points of simple dynamical systems, and study the local dynamics around these fixed points, in particular to discuss their stability and bifurcations.
3) Use a range of specialised analytical techniques which are required in the study of dynamical systems.
4) Describe dynamical systems geometrically and represent them graphically via phase plane analysis.
5) To find fixed points and period orbits of discrete dynamical systems, and find their stability.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2			2	2	2	2	1	2	2	2
CO2	3	3	2	2			2	2	2	2	1	2	2	2
CO3	3	3	2	2			2	2	2	2	1	2	2	2
CO4	3	3	2	1			2	2	2	2	1	2	1	2
CO5	3	3	2	2			2	2	2	2	1	2	2	2

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD06	3	1	0	4 HOURS	100	4

Paper Code: MaPhD06

GEOMETRY OF FINSLER SPACE

Course Objective: A course on Geometry of Finsler Space aims to introduce students to:

1) To understand the basic concepts of Finsler Space.
2) To learn Berwald and covariant differentiation.
3) To understand the concept Lie differentiation and its transformations.
4) To analyze how Riemannian curvature involved in the study of Finsler Geometry..
5) To study the application of Finsler Geometry in different branches of Applied Sciences.

Course Contents:

Basic concepts of Finsler space.

Berwald and Cartan covariant differentiation.

Lie differentiation of a tensor, Lie differentiation of Berwald connection coefficients, different commutation formulae, Motion, affine motion and projective motion, Conformal transformations.

Riemannian curvature, isotropic point, Shur's theorem, Szabo's theorem.

Books Recommended:

1. H. Rund, The Differential Geometry of Finsler Spaces, Springer-Verlag, Berlin, 1959.
2. M. Matsumoto, Foundations of Finsler Geometry and Special Finsler Spaces, Kaisheisha Press, Otsu, 1986.
3. P. L. Antonelli (ed.), Handbook of Finsler Geometry, Kluwer Academic Publishers, Dordrecht, the Netherlands, 2003.
4. D. Bao, S.S. Chern and Z. Shen, An Introduction to Riemannian-Finsler Geometry, GTM, Springer, 2000.
5. S.S. Chern and Z. Shen, Riemannian-Finsler Geometry, World Scientific, 2004.
6. Z. Shen, Lectures on Finsler Geometry, Lectures on Finsler Geometry, World Scientific, 2001.

Course Outcomes: Students will be able to:

1) Learn basic concepts of Finsler geometry.
2) Know the Cartan and Berwald covariant differentiation.
3) Understand the Lie differentiation.
4) Understand better the topics covered in allied courses like Riemannian geometry, Mathematical Physics and their applications.
5) Pursue research in Finsler geometry.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	1				1	1	1	2	1	1	3
CO2	3	2	2	1				2	1	2	2	1	1	2
CO3	3	2	2	1				2	2	2	2	1	1	2
CO4	3	2	2	3				2	1	1	3	1	1	3
CO5														

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD07	3	1	0	4 HOURS	100	4

Paper Code: MaPhD07

STRUCTURES ON MANIFOLDS

Course Objective:

1) To understand the basic concepts of manifolds.
2) To learn Torsion tensor of an affine connection, Curvature tensor of an affine connection.
3) To study almost complex manifold, Almost Hermite manifold, Kaehler Manifolds, Nearly Kaehler Manifolds and Para Kaehler Manifolds.
4) To study different type of flat spaces/manifolds.
5) To study the applications of complex manifolds in physics and cosmology.

Course Contents:

Manifolds and Connections: Concepts of manifolds, Tangent vectors, Vector fields, Lie Brackets, Affine connections, Torsion tensor of an affine connection, Curvature tensor of an affine connection. Complex and Almost Complex Manifolds: Definition and example, Nijenhuis tensor, Eigen Values of an almost complex structure, Existence theorem and inerrability condition, contravariant and covariant almost analytic vector fields.

Almost Hermite Manifolds: Nijenhuis tensor, Almost analytic vector fields, Curvature in almost Hermite manifold, Holomorphic Sectional Curvature, Linear connection in an almost Hermite manifold.

Koehler Manifolds: Holomorphic Sectional Curvature, Bochner Curvature tensor, affine connection in almost Kaehler manifold.

Nearly Kaehler Manifolds: Definition, Projective correspondence between two Nearly Kaehler manifolds, Curvature identities.

ParaKaehler Manifolds: Definition, Curvature Identities and conformal flatness of ParaKaehler manifold.

Reference Books:

1. K. Yano and M. Kon, Structures on Manifolds, World Scientific, 1984.
2. D. E. Blair, Riemannian geometry of Contact and Symplectic Manifolds, Progress in Mathematics, Vol. 203, Birkhäuser Inc., Boston, MA, 2002.
3. R. S. Mishra, Structures on Differentiable Manifolds and their Applications, Chandrama Prakashan, Allahabad, 1984.
4. U. C. De and A. A. Shaikh, Complex Manifolds and Contact Manifolds, Narosa.

Course Outcomes: They are able to understand:

1) Basics of almost manifolds like Almost Hermite manifold, Kaehler Manifolds, Nearly Kaehler Manifolds and Para Kaehler Manifolds.
2) Existence theorem and integrability condition, contravariant and covariant almost analytic vector fields in almost complex manifolds.
3) Nijenhuis tensor and their properties in different complex Manifolds.
4) Different types of curvatures in different complex manifolds.
5) Different type of flat spaces/manifolds and their applications in Physics and Cosmology.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	2			2	2	2	3	3	2	1
CO2	2	3	3	3	3			3	2	3	3	3	2	1
CO3	2	3	3	3	3			2	1	2	3	3	2	1
CO4	2	3	2	3	3			1	1	2	2	3	2	1
CO5	2	3	3	3	3			1	2	2	3	3	2	1

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD08	3	1	0	4 HOURS	100	4

Paper Code: MaPhD08

FIXED POINT THEORY AND APPLICATIONS

Course Objective: The objective of this course is:

1) To motivate and equip the students with basis in topological as well as metric fixed point theory. Students will be able to understand linear operator, and first contraction principle.
2) To understand the approximate iteration technique via applications.
3) To understand the fixed point theorem given by Brouwer's with proving technique.
4) To understand various other fixed point theorems that is. Browder, Schaude's, and Tychonoff's Theorems.
5) To understand the concepts of lipschitzian operators, and various iterative techniques.

Course Contents:

Introduction to metric fixed-point theory, Contraction Mapping in a Metric Space, Linear Operators, Some generalizations of the Contraction Mappings, Approximate Iteration.

A Converse of the Contraction Principle; Some Applications of the Contraction Principle. Examples and applications.

Brouwer's Fixed Point Theorem, equivalent Formulations; The Elementary Proof of Brouwer's Fixed Point Theorem; Examples and Applications.

The Schauder Fixed Point Theorem; Darbo's Generalization of Schauder's Fixed Point Theorem; Browder's and Fan's Generalizations of Schauder's and Tychonoff's Fixed Point Theorem.

Nonlinear Operators, Lipschitzian Mappings, Picard Iterative Method, Mann Iterative Method, Ishikawa Iterative Method, a few convergence theorems.

Reference Book:

1. Vasile I. Istratescu, Fixed Point Theory; D. Reidel Publishing Company; 90-277-1224-7.
2. Vasile Berinde "Iterative Approximation of Fixed Points" Springer.
3. Saleh Almezel, Qamrul Hasan Ansari, Mohamed Amine Khamsi, Topics in Fixed Point Theory, Springer.

Course Outcomes: This course will enable the students to:

1) Differentiate the metrical and topological fixed point theory. Understand the contraction mapping principle with various computational examples.
2) Elaborate approximate iteration technique via applications.
3) Explain the concepts of Brouwer's with proving technique.
4) Explain the concepts of Browder, Schaude's, and Tychonoff's Theorems.
5) Elaborate various iterative methods to obtain fixed points, like Picard's, Mann, Ishikawa iteration methods.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	1	3	3	2	1	3	2	3	1	2	3	1
CO2	3	2	1	2	3	2	1	3	3	3	1	2	3	1
CO3	3	3	1	3	3	2	1	3	2	3	1	2	3	1
CO4	3	3	2	3	3	2	1	3	3	3	1	2	3	1
CO5	3	3	2	3	3	2	1	3	3	3	1	2	3	1

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD09	3	1	0	4 HOURS	100	4

Paper Code: MaPhD09

MECHANICS OF SOLIDS AND WAVE PROPAGATION

Course Objective: A course on Mechanics of Solids and Wave Propagation aims to introduce students to:

1) Introduction to continuum mechanics and detail analysis about the stress.
2) To give the analysis of strain and Mohr's diagram.
3) To provide the Generalised Hook's law and its details.
4) To discuss the seismic wave propagation in elastic media.
5) To discuss the reflection and transmission phenomena in elastic media.

Course Contents:

Introduction to Continuum Mechanics, Basic definitions of Solid Mechanics, Principles of Elasticity, Fundamentals of Tensor Calculus, Body and Surface forces, Effects of force: tension, compression and shear, Analysis of stress, principal stresses, principal planes, maximum shearing stresses, Computation of Traction Vector and Principal Axes.

Introduction to Strain, Affine Transformation, Infinitesimal Affine Deformation, Geometrical Interpretation of components of Strain, Principal Strains, Invariants, General Infinitesimal Deformation, Examples of Strain, Notations, Equations of Mohr's circle diagram, equations of deformation and strain, strain in form of displacement, compatibility concepts, need and physical significance.

Stress-strain relations, Generalized Hook's Law, different types of symmetry, density function, Airy's stress function, Poisson's ratio. Complementary Shear Stress, Shear Strain, Shear Modulus. Unit for elastic moduli, Relation between modulus of elasticity, modulus of rigidity and bulk modulus. Saint-Venant's Principle.

Wave equation, Solution of Wave equations, Seismic wave equation, Plane waves, Harmonic plane wave equation, Polarization of P and S waves, Wave propagation in unbounded elastic medium.

Study of propagation of waves in elastic, viscoelastic and poroelastic media, Waves in anisotropic medium, thermoelastic medium, study of surface waves (Rayleigh & Love waves) in elastic and viscoelastic medium including layered medium, Reflection and refraction of waves in elastic media.

Reference Book:

1. Kazimi, SMA., (2013) Solid Mechanics, McGraw Hill Education (India) Pvt Ltd.
2. Love, A.E.H. *A Treatise on Mathematical Theory of Elasticity*, Cambridge University Press, New York.
3. Sokolnikoff, I.S., (1956) *Mathematical Theory of Elasticity*, McGraw Hill Book Co., New-York.

4. Biot, M .A. (1965) *Mechanics of* Incremental Deformations, John Wiley & Sons , New-York.
5. Ewing, W.M., (2018) *Elastic Waves in Layered Media*, Creative Media Partners, LLC.
6. Achenbach, J.D., (2012) *Wave Propagation in Elastic Solids*, North Holland, Elsevier.

Course Outcomes: This course will enable the students to:

1) Find the stress and the basic concept of continuum mechanics.
2) Evaluate the strain components.
3) About the detail study of Generalised Hook's law and its application.
4) Characterize the seismic wave nature.
5) Evaluate the amplitude and energy coefficients of the waves.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	1	2	2	2	2	2	1	3	1	3	3	1
CO2	3	3	1	2	2	2	2	2	1	3	1	3	3	1
CO3	3	3	1	2	2	2	2	2	1	3	1	3	3	1
CO4	3	3	1	2	2	2	2	2	1	3	1	3	3	1
CO5	3	3	1	2	2	2	2	2	1	3	1	3	3	1

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD10	3	1	0	4 HOURS	100	4

Paper Code: MaPhD10

ADVANCED NUMERICAL ANALYSIS

Course Objective:

1) To know about the computational procedure for solving algebraic and transcendental equations.
2) To know about the computational for solving linear systems.
3) To learns about the interpolation techniques.
4) To know about techniques for numerical integration.
5) To learn about the methods for finding Eigen value & Eigen vectors

Course Contents:

Errors and Approximations: Rate of convergence of an Iterative method, Efficiency index of an Iterative method,
Extension of Newton-Raphson method for finding multiple roots and to solve system of non-linear equations. Mullers method, Chebyshev's methods.

System of linear equations: LD decomposition techniques and its complexity analysis.

Interpolation: Newton's Divided difference method. Hermite's interpolation. Cubic spline interpolation. Errors in interpolation.

Numerical Integration: Method of undetermined coefficients. Errors in integration formulae. Iterative solution of linear equations.

Eigen values & Eigen Vectors: Bounds on eigen values, method for finding eigen values of symmetric matrices, method for finding eigen values of arbitrary matrices, method for finding largest eigen values of matrices.

Reference Book:

1. Jain M K, Iyengar S R K and *Jain* R K, Numerical Methods for Scientific and Engineering Computation, 4th Edn, New Age International Pvt Ltd (2005)
2. Jain M K, Numerical Solutions of Differential Equations, 2nd Edn, John Wiley and Sons Ltd (1984)
3. S. S. Sastry, Introductory Methods of Numerical Analysis, 5th Edn. Prentice Hall of India.

Course Outcomes: Students will try to learn:

1) The computational procedure for solving algebraic and transcendental equations.
2) The computational for solving linear systems.
3) The interpolation techniques.
4) Techniques for numerical integration.
5) The methods for finding Eigen value & Eigen vectors.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	2	3	2	3	2	3	2	2	3	3
CO2	3	3	3	3	2	3	2	3	2	3	2	2	3	3
CO3	3	3	3	3	2	2	2	3	2	3	2	2	2	2
CO4	3	3	2	3	2	3	2	3	2	3	2	2	3	3
CO5	3	3	3	3	3	3	2	3	2	3	2	2	3	3

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD11	3	1	0	4 HOURS	100	4

Paper Code: MaPhD11

ITERATIVE METHODS FOR SOLVING NONLINEAR EQUATIONS

Course Objective:

1) To know the classifications of iterative methods (IMs) and important related concepts.
2) To know some two-point without memory iterative methods (IMs).
3) To understand non-optimal two-steps iterative methods (IMs) for multiple roots.
4) To make aware about two-steps with memory iterative methods (IMs).
5) To learns two-steps higher order optimal & non-optimal iterative methods (IMs) .

Course Contents:

Errors and Approximations: Rate of convergence of an Iterative method, Efficiency index of an Iterative method.

Classification of iterative methods, computational order of convergence (COC), *R*-order of convergence, computational efficiency of iterative methods, initial approximations, stopping criteria, one point iterative methods for simple roots.

Two-point without memory IM: Traub's two-point IM, Owtrowski's fourth order IM & its generalization, Kung-Traub's multipoint IM, Jarratt's type IM, Non-optimal two-point IM for multiple zeros, optimal two-point IM for multiple zeros.

Two-point with memory IM: Secant like method, Steffensen like method, two-step method with memory of Neta's type.

Higher order IM: Non-optimal IM, optimal IM, with derivative IM, derivative free IM, Higher order without memory IM, higher order with memory IM.

Reference Book:

1. M. S. Petkovic, B. Neta, L.D. Petkovic, J. Dzunic (2013): Multipoint iterative methods for solving nonlinear equations, Elsevier, MA, USA.
2. J. F. Traub (1982): Multipoint iterative methods for solution of equations, Chelsea Publishing Company, NY, USA.
   C. T. Kalley (1995): Iterative methods for linear and nonlinear equations, SIAM, Philadelphia.

Course Outcome: Students will try to learn:

1) The classifications of iterative methods (IMs) and important related concepts.
2) Some two-point without memory iterative methods (IMs).
3) Understand non-optimal two-steps iterative methods (IMs) for multiple roots.
4) Aware about two-steps with memory iterative methods (IMs).
5) Learn two-steps higher order optimal & non-optimal iterative methods (IMs).

Course Outcomes and their mapping with Programme Outcomes:

CO	PO									PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	2	2	3	2	3	2	3	2	2	3	3
CO2	3	3	3	3	2	3	2	3	2	3	2	2	3	3
CO3	3	3	3	3	2	2	2	3	2	3	2	2	2	2
CO4	3	3	2	3	2	3	2	3	2	3	2	2	3	3
CO5	3	3	3	3	3	3	2	3	2	3	2	2	3	3

Weightage: 1-Sightly, 2-Moderately, 3-Strongly

SUB CODE	L	T	P	DURATION/WEEK	TOTAL MARKS	CREDITS
MaPhD12	3	1	0	4 HOURS	100	4

Paper Code: MaPhD12

FRACTIONAL CALCULUS

Course Objective: A course on Fractional Calculus aims to introduce students to:

1) This paper is to develop the advanced concept of Fractional Calculus with the special interest recurrence relations.
2) To learn the students time space fractional diffusion equations and boundary value problems.
3) It is necessary to introduce the functional future through suitable approximations being at least valid in specific frequency range featuring high accuracy of approximation and preferably not causing inadequate increase complexity of the final circuit solution etc.
4) To understand the developed of research orientation.
5) To learn application in science and engineering etc.

Course Contents:

Advance concept of Gamma and Beta function, Bessel functions.

Hyper-geometric and generalized hyper-geometric functions: Definition and some identities, Recurrence formulae and Expansion formulae.

Mittag-Leffler and Generalized Mittag-Leffler functions and its applications.

Introductions and definitions of Riemann-Liouville's fractional differential and Riemann-Liouville's fractional integral of order α. Basic properties of fractional integrals,

The Weyl fractional: Basic properties of Weyl integral with its applications.
Kober operators and generalized Kober operators.

Reference Book:

1. Special functions: Earl D. Rainville, Chelsea publishing Company, Bronx, New York.
2. The H-functions of one and two variables with applications: H. M. Shrivastava, K. C. Gupta and S. P. Goyal, South Asian Publishers Pvt. Ltd.
3. An introduction to the fractional calculus and fractional differential equation: Kenneth S. Miller and Bertram Ross, John Wiley & Sons, Inc. New York.
4. Special function for applied scientists: A. M. Mathai and Hans J. Haubold, by Springer publishers.
5. The H-function with application in statistics and other disciplines; A. M. Mathai and R. K. Saxena, Publishing John Wiley & Sons, New York.
6. The H-function Theory and application, A. M. Mathai, Ram Kishore Saxena and Hans J. Haubold, by Springer publishers.

Course Outcome:

1) The students will be able to solve differential equations of arbitrary order etc.
2) This course will help to develop the extended mathematical modelling of fractional order in science and engineering.
3) A General framework for global, non-adaptive identification of fractional and non-rational systems in general has been developed in several specific directions.
4) To important fractional -order digital/ analogue function blocks especially in medical signal processing.
5) Utilize fractional-order adjustment rule to model reference adaptive control in engineering, bio-engineering, bio-medical and its applications etc.

Course Outcomes and their mapping with Programme Outcomes:

CO	**PO**									**PSO**				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2								3				
CO2	3	2								3				
CO3	2	2								2				
CO4	2	2								2				
CO5	1	2								1				

Weightage: 1-Sightly, 2-Moderately, 3-Strongly