COTTON UNIVERSITY
DEPARTMENT OF MATHEMATICS
Ph.D. Course Work Syllabus

DISTRIBUTION OF PAPERS/CREDITS (L+T+P format)

	Paper Code	Paper Name	Credits
Paper 1	PCM2500RM	Research Methodology	**3+0+1**
Paper 2	MTH2501C	Linear Algebra and Analysis	**3+1+0**
Paper 3 (Special Paper)	MTH2502SP1	Fuzzy sets and applications	**3+1+0**
	MTH2502SP2	Advanced Graph Theory	**3+1+0**
	MTH2502SP3	Rings and Modules	**3+1+0**
	MTH2502SP4	Fluid Dynamics	**3+1+0**
	MTH2502SP5	Algebraic Graph Theory	**3+1+0**
	MTH2502SP6	Commutative Algebra	**3+1+0**
	MTH2502SP7	Theory of Distributions and Sobolev Spaces	**3+1+0**
	MTH2502SP8	Banach Algebra an Operator Theory	**3+1+0**
	MTH2502SP9	Graphs and Matrices	**3+1+0**
	MTH2502SP10	Finite Group Theory	**3+1+0**
	MTH2502SP11	Functional Analysis and its application	**3+1+0**
Paper 4	RPE2503GP	Research Publication and Ethics	**2+0 +0=2**

PAPER CODE: PCM2500RM
PAPER NAME: RESEARCH METHODOLOGY
CREDIT 4 (3+0+1)

[For the Departments of Physics, Chemistry, Mathematics, Computer Sciences &IT and Statistics]

Unit 1: Introduction to Research Methodology
Meaning and objectives of research, Types of Research, Qualitative and Quantitative approaches ofresearch, Criteria of good research, Research problem, Importance of defining the research problem, Techniques involved in defining aresearch problem, Illustration of research problem,Characteristics of Scientific method, Research Process, Literature survey

Unit 2: Hypothesis and research methodology
Research Design: Meaning, Importance of designing of research, Features of a good researchdesign, Design of Exploratory Research and Descriptive Research
Experimental Design: Concept of Independent & Dependent variables.Concept of Hypotheses, Characteristics of Hypothesis, Null hypothesis & Alternative Hypothesis
Hypothesis Testing –Logic & Importance

Unit 3: Data collection and analysis
Observation and collection of data- primary and secondary data, Methods of collection of data- Sampling methods, Data processing and analysing strategies, Data analysis with statistical methods, Hypothesis testing, Generalization and Interpretations

Unit 4: Scientific paper writing
Research communication and publication, when and where to publish, Layout of a research paper, Journal impact factor and citation, Scientific Citation Index and Extended List, H-index and i-10 index

Unit 5: Ethics in Research, Copyright and Intellectual Property Rights
Brief introduction to ethics and etiquettes in research with reference to honesty in scientificcommunication, reporting data, fabricating, falsifying and misinterpreting data

Plagiarism: Definition, various forms of plagiarism, self plagiarism, software for checking plagiarism

Intellectual property rights: Intellectual property and intellectual property rights, patent, trade mark,industrial design, geographical indication, copyright laws, world intellectual property organization.

Reference

1. Research Methodology-Methods and Techniques 2/e by C. K. Kothari, New Age International, New Delhi, 2004.
2. Research Methodology: A Step by Step Guide for Beginners 2/e by R. Kumar, Pearson India, 2005.
3. Statistics By T. R. Jain & S. C. Aggarwal, VK Enterprises, India.
4. The Researcher's Bible by A. Bundy, B. D. Boulay, J. Howe and G. Plotkin, University of Edinburgh, 1995
5. Reports and mannuals available in the official website of IPO (www.ip india .nic.in/) and WIPO (www. wipo .int/).

[**<u>For Credit 1</u>: The students have to prepare a report of literature survey (up to 3000 words) on a research topic assigned to him/her and submit the same to the concerned department before 2 (two) weeks of the final Course Work Examinations. This credit is in lieu practical (P) as stated in the L+T+P credit format**]

PAPER CODE: MTH2501C
PAPER NAME: LINEAR ALGEBRA AND ANALYSIS

CREDIT 4 (3+1+0)

Unit 1: Euclidean space, coordinate system in E_n, Classification of quadrics in three dimensional Euclidean space.

Least-square solutions and generalized inverses of a matrix, application of {1}-inverses to solution of linear equations, Moore-Penrose inverse, computation of the Moore-Penrose inverse, least-squares solutions of inconsistent linear equations.

Unit 2: Functions of several variables, linear transformations, differentiation, partial derivatives, contrapositive principle, inverse function theorem, implicit function theorem, rank theorem, determinants, Jacobians, derivatives of higher order, differentiation of integrals.

Unit 3: Homotopic version of Cauchy's theorem and simple connectivity, Cauchy's theorem (second and third version), independence of path theorem, Cauchy's theorem (fourth version), counting zeros-Open mapping theorem, Goursat's theorem.

Unit 4: Variational formulation, Lax-Milgram Theorem, Regularity estimates, Construction of Finite Element Space, Finite Element Approximation to initial and boundary value problem.

Reference

1. Principles of mathematical analysis, Walter Rudin, McGraw Hill Education (India) Private Limited, New Delhi

2. First course in linear algebra, P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul, Wiley Eastern Limited.

3. The Mathematical Theory of Finite Element Methods, S.C. Brenner and L.R. Scott, (Springer-Verlag, 1994).

4. An Introduction to the Finite Element Method, J. N. Reddy (McGraw-Hill, Inc., 1993).

5. J. B.Conway, Functions of One Complex Variable(2nd Edition),Narosa Publishing House, 1994

Special Papers

PAPER CODE: MTH2502SP1
PAPER NAME: FUZZY SETS AND APPLICATIONS

CREDIT 4 (3+1+0)

Unit 1: Interval numbers, Interval arithmetic, Multilevel interval numbers. Fuzzy numbers, Fuzzy numbers in the set of integers, Arithmetic with fuzzy numbers. Definition of fuzzy sets, Fuzzy sets and fuzzy numbers, Basic operations on fuzzy sets, Extension principle of fuzzy sets.

Unit 2: Fuzzy relations, Basic properties of fuzzy relations, Fuzzy relations and approximate reasoning.

Unit 3: Fuzzy logic, Linguistic variables, Linguistic modifiers, Truth, Propositions of fuzzy logic, Uncertainty based information,

Unit 4: Approximate reasoning. Fuzzy decision making, Multicriteria decision making, Multistage decision making, Fuzzy ranking methods. Fuzzy modeling of control parameters, Washing machine, Fuzzy logic control for a predator-prey system.

Reference

1. Fuzzy Set Theory: Foundation and Application, G. J. Klir, U. S. Clair and B. Yuan, Prentice Hall, 1997.
2. Fuzzy Set Theory and its Applications, H. J. Zimmermann, 3rd edition, Kluwer Academic, 1992.
3. Fuzzy Sets, Fuzzy Logic Applications, G. Bojadzieve and M. Bojadzieve, World Scientific, 1995.
4. Fuzzy and Neural Approaches in Engineering, L.H. Tsoukalas and R.E. Uhrig, John Wiley and Sons 1997.

PAPER CODE: MTH2502SP2
PAPER NAME: ADVANCED GRAPH THEORY

CREDIT 4 (3+1+0)

Unit 1: Graph, Intersection graph, Isomorphic graphs, Walks, Paths, Circuit, diameter, girth of graphs.

Unit 2: Coloring, Cliques, Chromatic no., Polynomial Chromatic no., Chromatic no. of special graphs Connectivity, Partitioning, Matching, Covering of graphs

Unit 3: Matrix Representation of Graphs, Incidence Matrix, Rank of Incidence Matrix, Circuit Matrix, Cut set Matrix, Path Matrix, Adjacency Matrix, Eigen values of graphs, Lower and upper bounds for the eigen values

Unit 4: Automorphism group of graphs, Cayley Graphs, Transitive graph, Vertex Transitive graph, Arch Transitive graph.

Reference:

1. Graph Theory With Application To Engineering and Computer Science- Narsing Deo, Prentice Hall India Learning Private Limited; New edition (1979)
2. Algebraic Graph Theory-Chris Godsil and Gordon Royle, Springer New York(2001)
3. Graph Theory-Frank Harary, Addison-Wesley Publishing Company, (1969)
4. Modern Graph Theory-Bela Bollobas , Springer-Verlag New York, (2004)
5. Introduction to Graph Theory- Douglas West B, Prentice Hall of India, (2001).

PAPER CODE: MTH2502SP3
PAPER NAME: RINGS AND MODULES

CREDIT 4 (3+1+0)

Unit 1: Rings and related algebraic systems, subrings, homomorphisms, ideals, modules, direct product and direct sums, classical isomorphism theorems.

Unit 2: Prime ideals in commutative rings, prime ideals in special commutative rings. The complete ring of quotients of a commutative ring, rings of quotients semiprime rings, prime ideal spaces.

Unit 3: Primitive rings, radicals, completely reducible modules, completely reducible rings, Artinian and Noetherian rings, on lifting idempotents, local and semiperfect rings.

Unit 4: Projective modules and injective modules.

Reference

1. Lecture on rings and modules, J. Lambek, Blaisdell Publishing Company
2. Ring Theory, K.R. Goodearl, Marcel Dekker, 1976.

PAPER CODE: MTH2502SP4
PAPER NAME: FLUID DYNAMICS

CREDIT 4 (3+1+0)

Unit 1: The continuum hypothesis, Fundamental Laws of Viscous Fluid, Real and perfect fluids, Newtonian and Non-Newtonian fluids - Continuity equation - Euler equation of motion - Navier-Stokes equations of motion. Exact solution of Navier-Stokes equations. Vortex flow.

Unit 2: Similarity principle and dimensional analysis. Physical interpretation of non-dimensional parameters, important non-dimensional co-efficients in the dynamics of viscous fluids. General outline of Boundary layer flow. Stokes flow, Oseen's approximation, idea of singular and regular perturbation, method of multiple scales adopted in solving singular perturbation problems.

Unit 3: Energy equation. Concept of thermal boundary layer, free and forced convection, theory of similarity in heat transfer, the thermal boundary layer equation in two dimensional flow. Exact solutions for the problem of temperature distribution in a viscous flow. Effect of Prandtl number, forced convection in laminar boundary layer on a flat plat, free convection from a hot vertical plate, thermal energy integral equation.

Unit 4: Introduction to magnetohydrodynamics, Maxwell's electromagnetic field equations, Equation of motion of a conducting fluid, rate of flow of change, the magnetic Reynolds number, the magnetic body force, Laminar flow of a viscous conducting fluid between parallel walls in transverse magnetic field.

Concepts of the porous media –porosities, permeability, Darcy's law.

Reference

1. An Introduction to Fluid Dynamics by G.K. Batchelor, Cambridge University Press.
2. Fluid Dynamics By M. D. Raisinghania, S Chand & Company, New Delhi
3. Boundary Layer Theory: H. Schlichting translated by J. Kertin, McGraw Hill, New York.
4. Fundamental Fluid Mechanics and Magnetohydrodynamics, by R. J. Hosking, R. L. Dewar, Springer
5. Modern Development of Fluid Dynamics, Vol –I by S. Goldstein, Dover Publication, New York.

PAPER CODE: MTH2502SP5
PAPER NAME: ALGEBRAIC GRAPH THEORY

CREDIT 4 (3+1+0)

Unit 1: Eigenvalues of graphs: Some examples. Eignvalus and walks, Eigenvalues and labllings of graphs, Lower bounds for the eigenvalues, Upper bounds for the Eigenvalues, Other matrices related to graphs, Cospectral graphs.

Unit 2: Spectral graph theory, Star sets and star partitions, Star completes, Exceptional graphs, Reconstructing the characteristic polynomial, Non-complete extended p-sums of graphs, Integral graphs

Unit 3: Graph Laplacians. The Laplacian of a graph, Laplace eigenvalues, Eigenvalues and vertex partitions of graph, The max-cut problem and semi-definite programming, Isoperimetric inequalities, The traveling salesman problem, Random walks on graphs.

Unit 4: Auromorphisms of graphs: Graph auromorphisms, Algorithmic aspects, Automorphisms of typical graphs, permutation groups, Abstract groups, Cayley graphs, Vertex-transitive graphs.

Unit 5: Distance-transitive graphs: Distance-transitivity, Graphs from groups, Combinatorial properties, imprimitivity, Bounds, Finite simple groups, The first step, The affine case, The simple scole case.

Unit 6: Computing with graphs and groups: Permutation group algorithms, Strong and accessing a G-graph, Constructing G-graphs, graph, G-breadth-first search in a G-graph, Automorphism groups and graph is isomorphism, Computing with vertex-transitive graphs, Coset enumeration, Coset enumeration for symmetric graphs.

Reference

1. Topics in Algebraic Graph Theory, L. W. Beinke and R. J. Wilson, Cambridge University Press

PAPER CODE: MTH2502SP6
PAPER NAME: COMMUTATIVE ALGEBRA

CREDIT 4 (3+1+0)

Unit 1: Extension and Contraction of ideals, Prime spectrum of Rings, Jacobson radical of a ring, Prime avoidance lemma, Rings of formal power series, Restriction and extension of scalars.

Unit 2: Localisation, Local properties, Extended & contracted ideals in rings of fractions, Primary decomposition, First and second uniqueness theorem of primary decomposition, Noetherian rings, Primary decomposition in Noetherian rings, Artin rings, Structure theorem for Artin rings.

Unit 3: Integral dependence, Going up theorem, Going down theorem, Integrally closed domains, Valuation rings, Hilbert's Nullstellensatz theorem, Discrete valuation rings, Dedekind domains, Fractional ideals.

Reference

1. Introduction to Commutative Algebra, M.F. Athiyah & I.G. Macdonald, Addison Wesley, 1969.
2. Basic Commutative Algebra, B. Singh, World Scientific Publishing Co., 2011.
3. Commutative Algebra with a view towards algebraic geometry, D. Eisenbud, Springer Verlag, 1995.
4. Commutative Algebra, Vol. 1 & 2, O. Zariski & P. Samuel, SpringerVerlag, 1975.
5. Steps in Commutative Algebra, R.Y. Sharp, Cambridge University Press, 1990

PAPER CODE: MTH2502SP7
PAPER NAME: THEORY OF DISTRIBUTIONS AND SOBOLEV SPACES

CREDIT 4 (3+1+0)

Unit 1: Measure, Lebesgue measure, Measurable functions, Lebesgue integration, L_p spaces.

Unit 2: Test functions, Distribution, Derivatives of Distribution, Some operations on Distribution, Fourier Transform, The inverse Fourier transform.

Unit 3: Sobolev spaces of integer order, Sobolev's inequality, Imbeddings, Fractional order spaces, Dual spaces, Trace Theorems.

Reference

1. Topics in Functional Analysis and Applications, S. Kesavan, Willey Eastern Limited, 1989.

2. A guide to Distribution Theory and Fourier Transforms, Studies in Advanced Mathematics, Robert S. Strichartz, CRC Press, USA, 1994.

3. Sobolev spaces, R. A. Adams and John J. F. Fourier, Academic Press, 2003.

4. Lebesgue Integration, Soo-Bong Chae, Springer-Berlag, 1994.

PAPER CODE: MTH2502SP8
PAPER NAME: BANACH ALGEBRA AND OPERATOR THEORY

CREDIT 4 (3+1+0)

(Preamble: This syllabus is designed to introduce the students to the topics of Banach algebra and Hilbert spaces. Knowledge expected is to be aware of the background concepts in algebra. The students are expected to know about Operators and fixed point theory. This will motivate the students to learn about various operators and their characteristics.)

Unit 1: Banach algebras –Complex Homomorphisms –Basic properties of Spectra, Group of invertible elements –Commutative Banach algebra –Ideals and Homomorphisms –Gelfand transforms (12 hours).

Unit 2: Bounded Operators on Hilbert spaces –Bounded Operators –A commutativity theorem –Resolution of the Identity –Spectral theorem, Eigen values of normal operators –Positive operators and square roots –Group of invertible operators (12 hours).

Unit 3: Fixed Point Theorems Contractions, Banach Contraction Principle, Theorem of Edelstein, Picard–Lindelof Theorem. Non expansive Maps, Schauder'sTheorem for non–expansive maps, Continuation Methods for Contractive and non–expansive mappings.Some Applications of The Banach Contraction Principle, Brief idea Applications of Fixed Point Theorems in Economics and Game Theory

Unit 4: Some Extensions of Banach Contraction Principle for Single – Valued Mappings, Generalized distances, Some Extensions of Banach Contraction Principle under Generalized Distances, Multivalued versions of Banach Contraction Principle. A brief idea of Orlicz fuction [

Reference

1. Functional Analysis, by Walter Rudin,Tata McGraw Hill, Chapters 10,11 & 12.

2. S. Almezel, Q. H. Ansari and M. A. Khamsi; Topics in Fixed Point Theory, Springer 2014.

3. R. P. Agarwal, M. Meehan, D. O' Regan; Fixed Point Theory And Applications, Cambridge University Press 2004.

4. K.C.Border; Fixed Point Theorems with Applications to Economics and Game Theory; Cambridge University Press 1985.

PAPER CODE: MTH2502SP9
PAPER NAME: GRAPHS AND MATRICES

CREDIT 4 (3+1+0)

Unit 1: Incidence Matrix, Rank, Minors, Path Matrix, 0-1 Incidence Matrix, Matching in bipartite graphs.

Unit 2: Adjacency Matrix, Eigenvalues of some graphs, Determinant, Bounds, Energy of a graph, Antiadjacency matrix of a directed graph, Non-singular trees.

Unit 3: Laplacian matrix, Basic properties, Computing Laplacian eigenvalues, Matrix-tree theorem, Bounds for Laplacian spectral radius, Edge-Laplacian of a tree.

Unit 4: Cycles and Cuts, Fundamental Cycles and fundamental cuts, Fundamental matrices, Minors.

Unit 5: Regular Graphs, Perron-Frobenius Theory, Adjacency algebra of a regular graph, Complement and line graph of a regular graph, Strongly regular graphs and friendship theorem, Graphs with maximum energy.

Reference

1. Graphs and Matrices, R.B.Bapat, Hindustan Book Agency, Springer.

2. Linear Algebra and Linear Models, R.B.Bapat, Second ed., Hindustan Book Agency, New Delhi and Springer, Heidlberg, 2000.

3. Graph Theory, J.A.Bondy and U.S.R. Murty, Graduate texts in Mathematics 244, Springer, New York, 2008.

4. Path matrices of a tree, R.B.Bapat and S.Pati, Journal of Mathematical Sciences, New Series (Delhi) 1:46-52 (2002).

PAPER CODE:MTH2502SP10
PAPER NAME: FINITE GROUP THEORY

CREDIT 4(3+1+0)

Unit 1: Group Action, Sylow's theorems and applications

Unit 2: Permutation groups, Transitive groups, Frobenius groups, Primitive action, Symmetric group

Unit 3: Commutators, Three-subgroup lemma, Nilpotent groups and nilpotent normal subgroups

Unit 4: Co-prime action, Frobenius action

Reference

1. Finite group theory-I. Martin Isaacs(Units I,III,IV)
2. The theory of finite groups-H.Kurzweil, B.Stellmacher(Units II, III)

PAPER CODE:MTH2502SP11
PAPER NAME: FUNCTIONAL ANALYSIS AND ITS APPLICATION

CREDIT 4(3+1+0)

Unit 1: Metric space, open set, closed set, neighborhood, convergence, Cauchy sequence, completeness.

Unit 2: Normed space, Banach space, Compactness, Linear operator, Bounded and continuous linear operator, linear functional.

Unit 3: Banach fixed point theorem, application of Banach’s theorem to linear equations, application to differential and integral equations.

Unit 4: Measure of noncompactness, Darbo’s fixed point theorem, its application on integral and differential equations.

Reference

1. Sequence spaces and Measures of Noncompactness with Applications to Differential and Integral Equations, Jozef Banas, Mohammad Mursaleen, Springer.
2. Introductory functional Analysis with applications, Erwin Kreyazig, John Wiley & Sons.