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The American College

(An Autonomous institution affiliated to Madurai Kamaraj University)

THE AMERICAN COLLEGE
DEPARTMENT OF MATHEMATICS
M.PHIL PROGRAM
BOARD OF STUDIES
27TH October 2019

THE AMERICAN COLLEGE, MADURAI

DEGREE OF MASTER OF PHILOSOPHY (M.Phil) IN MATHEMATICS

Eligibility: As per Madurai Kamaraj University norms.

Duration: One year consisting of two semesters.

Course of Study: I Semester: Papers: 1. Research Methodology
2. Core Paper- I
3. Core Paper- II
4. Elective Paper

II Semester: Dissertation

	Course	Title	Lect.	Self/Lib.	credits	Internal	External	Total
I Sem.	MPM 6500	Research Methodology	5	3	5	50	50	100
	MPM XXXX	Core Paper- I	4	3	4	50	50	100
	MPM XXXX	Core Paper- II	4	3	4	50	50	100
	MPM XXXX	Elective Paper	5	3	5	50	50	100
II Sem.	MPM 6800	Dissertation			8	100	100	200
		Seminars (2)			4	100		100
		Viva-voce			6		100	100
	Total				36			800

Core Papers: MPM 6401- ALGEBRA
MPM 6403- ANALYSIS
MPM 6405- ALGEBRAIC TOPOLOGY

Elective Papers: MPM 6501- ADVANCED TOPICS IN GRAPH THEORY

MPM 6503- FRACTAL GEOMETRY AND FUZZY MATHEMATICS

MPM 6505- ANALYTIC NUMBER THEORY

MPM 6507- ADVANCED TOPOLOGY

MPM 6509- ADVANCED FLUID DYNAMICS

MPM 6511- DIFFERENTIAL EQUATION

MPM 6513- ADVANCED FUNCTIONAL ANALYSIS

MPM 6515- STATISTICAL INFERENCE AND STOCHASTIC PROCESS

PROGRAMME SPECIFIC OBJECTIVES (PSOs) FOR M.PHIL MATHEMATICS

On completion of the programme, the research scholars will be able to

1. entrain oneself as a scholar with continuing reading habit and analytical skills to objectively look at things and propose innovative and original research according to the emerging demand.
2. equip themselves for independent learning and research.
3. keep on discovering new avenues in the chosen field and exploring areas that remain conducive for research and development.
4. assimilate complex and intricate mathematical concepts and use logical deductions for construction of irrefutable proof.
5. interpret and critically evaluate information from a range of sources that include books, scientific reports, journals, case studies and the internet.
6. do programming and coding in the recent software and languages. Explore the new frontiers of knowledge in Mathematics.
7. become a successful learner/ researcher in inter-disciplinary fields of study.
8. produce and defend an original contribution to knowledge, as evidenced by the writing and defense of a dissertation involving significant original research.
9. publish research articles in reputed journals.
10. contribute to the nation as an innovator by taking up research career afterwards.

Mapping of Programme Specific Outcomes Outcomes (PSOs) with Programme outcomes (POs)

Courses	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
PSO 1	X									
PSO 2		X			X					
PSO 3			X	X						
PSO 4		X		X						
PSO 5					X		X			
PSO 6						X				
PSO 7					X		X			
PSO 8								X	X	
PSO 9				X			X	X	X	
PSO 10										X

Mapping of Course Outcomes (COs) with Programme Specific outcomes (PSOs)

Courses	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
MPM 6500		X		X	X	X		X		
MPM 6401	X	X	X	X	X			X		
MPM 6403	X	X	X	X	X			X		
MPM 6501	X	X		X	X		X	X		
MPM 6800	X	X	X	X	X	X	X	X	X	X

MPM 6500 RESEARCH METHODOLOGY 5 Hrs/5 Crs

The aim of the course is to get prior idea on preparing research articles and dissertation in Mathematics. Also develop enough skills in LATEX so that students themselves able to prepare articles and dissertation in Mathematics.

At the end of the course, the students will be able to

i. provide the overview of research methodology.
ii. define and analyze the problem chosen by the students and know how to do the literature survey work and write the dissertation.
iii. use LATEX type -setting to frame the dissertation.
iv. analyze the topological concepts.
v. present the research works through PowerPoint presentation.

UNIT- 1: Meaning of research – objectives of research – Motivation of research – Types of research – Research approaches – Significance of research – Research methods versus Research methodology – Research and Scientific method – Importance of knowing how research is done – research process – criteria of Good research.

UNIT- 2: Theses and Dissertations-Defining the Problem-Limiting the problem – Consulting source material – preparing a working bibliography – Selecting a topic - Mathematical Journals – AMS subject classification (primary and secondary. Main subjects only) - Impact factor-citation index-search engines.

UNIT-3: Contents of LATEX source file – Document Class – Page style – Parts of the document – Changing font – Centering and indenting texts – Bibliography – Anatomy of and articles.

Drawing tools: Texcad/ Flash 5.0 / Concept draw.

UNIT-4: Problems and Theorems of Closed sets – Limit points – Continuity - Connectedness . Problems and Theorems of Compactness – Countability - T_0 , T_1, T_2 and regular spaces.

UNIT-5: Study of any research article in Topology – Named theorems in Separation Axioms (PPT Presentations by the Students).

TEXT BOOKS:

1. Research Methodology: Methods and Techniques by C.R. Kothari, New age international publishers, (1990).

2. Charting a Course for a Successful Research career by Prof.Alan M Johnson AM, Elsevier, Second Edition (2011).
3. A guide to LATEX- Fourth Edition by H. Kopha and P.W. Daly, Addision-Wesley, London.
4. Theory and problems of general Topology by Seymour Lipschutz, Mc Graw Hill, International Edition (2010).
5. Topology (Second Edition) by James R. Munkres, Prentice – Hall of India, Private Ltd, New Delhi, 2006.

Bloom's Taxonomy	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**
K1: Remembering	X				
K2: Understanding			X		
K3: Applying		X			X
K4: Analyzing	X			X	
K5: Evaluating					
K6: Creating			X		

MPM 6401 ALGEBRA 4 Hrs/4 Crs

This course will provide a strong foundation in the abstract approach for the budding Mathematician. One of the amazing features of twentieth century Mathematics has been its recognition of the power of abstract approach. Also it enable students to acquire research idea in Algebra and create awareness to do research work.

At the end of the course, students will be able to

i. discuss fundamental group and covering spaces.
ii. define modules and discuss its characteristics.
iii. explain the structure of modules
iv. outline the structure of rings
v. analyze prime and primary ideals and demonstrate Noetherian Rings with examples .
vi. understand the properties of different types of ideals; • recognize the concept of a module and their constructions;

vii. understand the properties of modules of fractions; • recognize the properties of tensor product of algebras; • understand the Extension fields, their types and characterizations.

UNIT 1: RINGS AND IDEALS (CHAPTER 1)

Rings and ring homomorphisms – Ideals - Quotient rings - Zero-divisors - Nilpotent elements - Units - Prime ideals and maximal ideals - Nilradical and Jacobson radical - Operations on ideals - Extension and contraction.

UNIT 2: MODULES (CHAPTER 2)

Modules and module homomorphisms – submodules and quotient modules – Operations on submodules – Direct sum and product – Finitely generated modules – Exact sequences.

UNIT 3: RINGS AND MODULES OF FRACTIONS (CHAPTER 3 - PAGE NO: 17-22)

Local properties - Extended and contracted ideals in rings of fractions.

UNIT 4: PRIMARY DECOMPOSITION, INTEGRAL DEPENDENCE AND VALUATIONS (CHAPTER 4, 5)

Primary decomposition – Integral dependence – The going-up theorem – Integrally closed integral domains – The going-down theorem – valuation rings.

UNIT 5: CHAIN CONDITIONS, NOTHERIAN AND ARTIN RINGS (CHAPTER 6, 7, 8)

Chain conditions - Primary decomposition Noetherian Rings – Artin rings.

TEXT BOOK:

1. M.F. Atiyah and I.G. Macdonald, Introduction to commutative Algebra, Addison-Wesley Publishing company, London.

REFERENCE BOOKS:

1. Pierce R.S., “Associative Algebras, Graduate Texts in Mathematics”, Springer Verlag, NewYork, 1982.
2. Rudin W., “Real and Complex Analysis”, Tata Mc-Graw Hill, Third Edition, 2006.
3. Non-Commutative Rings, I.N. Herstein, John Wiley and Sons, Inc., Chapters I&II, Pages 1-68.
4. Introduction to Rings and Modules 2nd Edition, C. Musili, Narosa Publishing House, New Delhi; Chapter-II: Pages 33 - 65.
5. F.W. Anderson and K.R.Fuller, Rings and Categories of Modules, 2nd Edition, Graduate Texts in Mathematics, Vol.13, Springer – Verlag, New York, 1992.

6. Lecture Notes on Elementary Topology, I.M.Singer and J.A.Thotpe, Springer Verlag, New York, 1967 .
7. Algebra By Thomas W.Hungerford, Springer 1974.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering	X				
K2: Understanding		X	X	X	X
K3: Applying		X			X
K4: Analyzing	X		X		
K5: Evaluating				X	
K6: Creating					

MPM6403 ANALYSIS 4 Hrs/4 Crs

The aim of the course is to provide every M.Phil student a comprehensive idea about of Real Analysis. This course will provide such treatment through understanding the concept of measurability, complex differentiation, Holomorphic functions, Fourier transformations and Riemann Integration. Mathematics itself, where these concepts are inseparable in all of pure Mathematics as it is today. Also it enable students to acquire research idea in real analysis and create awareness to do research work in Analysis.

At the end of the course, students will be able to

i. discuss measurability and integration of functions.
ii. explain the generalization of complex differentiation along with power series representation and calculus of residues.
iii. outline the importance of Fourier transformations and their properties.
iv. categorize Riemann and Lebesque integral of bounded functions.
v. demonstrate with examples and counter examples of general Lebesque integral and the convergence of measure.

UNIT 1: ABSTRACT INTEGRATION

The concept of measurability – Simple functions – Elementary properties of measures – Integration of positive functions – Integration of complex functions – The role played by the sets of measure zero.

UNIT 2: ELEMENTARY PROPERTIES OF HOLOMORPHIC FUNCTIONS

Complex differentiation – Integration over paths – The local Cauchy theorem – The power series representation – The open mapping theorem – The global Cauchy theorem – The calculus of residues.

UNIT 3: FOURIER TRANSFORMS

Formal properties – The inversion theorem – The Plancheral Theorem - The Banach algebra L' – Two theorems of Paley and Wiener.

UNIT 4: RIEMANN INTEGRAL

Riemann integral - The Lebesgue integral of bounded function over a set of finite measure- The integral of a non-negative function.

UNIT 5: GENERAL LEBESGUE INTEGRAL

The general Lebesgue integral-Convergence in measure.

REFERENCE BOOKS:

1. Rudin W., "Real and Complex Analysis", Tata Mc-Graw Hill, Third Edition, 2006.
2. Measure Theory, Paul R. Halmos, Springer 1974.
3. Real Analysis, Royden, H.L., The Macmillan Company, New York, Third Edition, 1988.
4. Complex Analysis, Elras, M. Stein and Ramishakarchi, Princeton University Press, 2003.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering	X				
K2: Understanding		X	X	X	
K3: Applying		X			X
K4: Analyzing	X		X		
K5: Evaluating				X	
K6: Creating					

MPM 6405 ALGEBRAIC TOPOLOGY 4 Hrs / 4 Crs

The aim of the course is to enable them in the Algebric Topology and its applications and to train them in the field of Topological Algebra to make them expert.

At the end of the course, the students will be able to

i. define homotopic maps, homotopy type, retraction and deformation retract, extend the concept and calculate the fundamental groups of n-sphere.
ii. discuss the concepts of the cylinder, the torus, and the punctured plane. Apply the Brouwer fixed-point theorem and fundamental theorem of algebra.
iii. explain covering projections, the lifting theorems, relations with the fundamental group.
iv. identify and analyze the classification of covering spaces, Universal covering space.
v. conceptualize more intrinsic and inherent advantages of the Borsuk-Ulam theorem, free groups, Seifert –Van Kampen theorem.

UNIT- 1: Homotopic maps, homotopy type, retraction and deformation retract. Fundamental group. Calculation of fundamental groups of n-sphere, $n \geq 1$.

UNIT- 2: The cylinder, the torus, and the punctured plane. Applications: TheBrouwer fixed-point theorem, the fundamental theorem of algebra.

UNIT- 3: Covering projections, the lifting theorems, relations with the fundamental group.

UNIT- 4: Classification of covering spaces, Universal covering space.

UNIT- 5: The Borsuk-Ulam theorem, free groups, Seifert –Van Kampen theorem. Applications of Seifert –Van Kampen theorem

REFERENCE BOOKS:

1. M.A. Armstrong, Basic Topology, Springer Verlag, 1983
2. G.E.Bredon, Geometry and Topology, Springer Verlag, 1993
3. W. Massey, A Basic Course in Algebraic Topology, Springer-Verlag, Berlin, 1991.
4. J.J.Rotman, An Introduction to Algebraic Topology, Springer-Verlag, Berlin, 1988
5. J.J. Rotman, An Introduction to Algebraic Topology, Springer (India), 2004.

Bloom's Taxonomy	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**
K1: Remembering	X				
K2: Understanding		X	X	X	X
K3: Applying		X			X
K4: Analyzing			X	X	
K5: Evaluating					
K6: Creating	X				

ELECTIVE PAPERS

MPM 6501 ADVANCED TOPICS IN GRAPH THEORY 5 Hrs/5 Crs

Graph Theory is an important branch of Mathematics which has plenty of applications in almost all other fields such as Physics, Chemistry, Operations Research, Management, Sociology, Linguistics, Computer Engineering, Electrical Engineering, etc. The objective of the course is to cover very recent areas of Graph Theory, so that interested students can continue their research in this area.

At the end of the course, students will be able to

i. discuss Eulerian/ Hamiltonian graphs and study their properties.
ii. use the applications of different parameters of a graph.
iii. validate and critically assess the different types of coloring.
iv. apply the distance concept in graphs.
v. define different types of domination and study its real life applications.

UNIT 1: TRAVERSABILITY

Eulerian graphs – Hamiltonian graphs – Exploration: Hamiltonian walks and numbers – Excursion: The early books of Graph theory.

UNIT 2: FACTORIZATION AND DECOMPOSITION

Factorization – Decompositions and Graceful labeling – Excursion: the Petersen graph and Exploration: gamma labeling of graphs.

UNIT 3: COLORING

The four color problem – vertex coloring – edge coloring – Excursion: the Heawood map coloring theorem and Exploration: Local coloring.

UNIT 4: DISTANCE

The Center of a graph – Distant vertices – Excursion: Locating numbers - Excursion: detour and directed distance - Exploration: Channel assignment and Exploration: Distance between graphs.

UNIT 5: DOMINATION

The domination number of a graph – Exploration: stratification - Exploration: Lights out and Excursion: And Still it grows more colorful.

REFERENCE BOOKS:

1. Gary Chartrand and Ping Zhang, A first course in graph theory, Dover Publications, New York, 2012.

2. Teresa W. Hayness, Stephen T. Hedetniemi, Peter J. Slater, & Marcel Dekker, Fundamental of Domination in Graphs, INC New York, 1998.
3. F. Harary – Graph Theory, Addison Wesley publishing house, 1972.
4. G. Chartrand and O. R. Oellerman – Applied and Algorithmic Graph Theory, Mcgraw Hill, 1993.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering		X			
K2: Understanding	X			X	
K3: Applying		X		X	X
K4: Analyzing	X		X		
K5: Evaluating					
K6: Creating					X

MPM 6503 FRACTAL GEOMETRY AND FUZZY MATHEMATICS 5 Hrs/5 Crs

To provide the basic ideas of Fractal Geometry and Fuzzy set theory to motivate the students to convert the real life situations in analytical representations.

At the end of the course, students will be able to

i. demonstrate space of fractals transformations on metric spaces.
ii. illustrate fractal dimensions and its consequences.
iii. discuss fuzzy operations and relations.
iv. analyze various measures in fuzzy.
v. classify the types of measures of uncertainty and illustrate its classical measures.

UNIT 1: Classical fractals and self similarity , Metric spaces, Equivalent spaces and Space of fractals Transformations on metric spaces , Contraction mappings and the construction of fractals , contraction mapping theorem, condensation sets, collage theorem.

UNIT 2: Chaotic dynamics on fractals, Addresses of points on fractals, continuous transformations from code space to fractals and introduction to dynamical systems. Fractal dimension, the box counting theorem, Julia sets, IFS whose attractors are Julia sets, parameter spaces and Mandelbrot sets.

UNIT 3: Basic fuzzy operations and related theorems, fuzzy relations, binary relations, equivalence and similarity relations and orderings, fuzzy relation equations.

UNIT 4: Fuzzy measures, belief and plausibility measures, probability measures.

UNIT 5: Types of uncertainty, measures of fuzziness and classical measures of uncertainty.

REFERENCE BOOKS:

1. M.F. Barnslay, Fractals everywhere, academic press, 1990.
2. G.A Edgar, Measure, Topology and fractal geometry, Springer verlag, 1990.
3. G.J.Klir and T.A Folger, Fuzzy sets, Uncertainty and Information, Prentice Hall of India, 2001.
4. G.J.Klir and Bo. Yuan, Fuzzy sets and fuzzy logic, their applications, Prentice Hall of India, 1997.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering					
K2: Understanding			X		X
K3: Applying	X	X			X
K4: Analyzing				X	
K5: Evaluating					
K6: Creating					

MPM6505 ANALYTIC NUMBER THEORY 5 Hrs/5 Crs

To make enable the scholars to get exposed to the frontier areas of analytic Number theory. This course deals with the applications of analysis in number theory and partition theory.

At the end of the course, students will be able to

i. discuss arithmetic functions and its averages space of fractals transformations on metric spaces.
ii. distinguish the Dirichlet Characters
iii. explain Dirichlet series and Euler product.
iv. discuss the various concepts of partitions.

v. demonstrate asymptotics of infinite product generating function and its congruences properties.

UNIT 1: Arithmetical functions: Dirichlet product, Mobius inversion formula, Mangoldt function, Lioville's function, Divisor functions, Generalised inversion formula, Bell series, Derivatives of arithmetical function, Selberg identity. Averages of arithmetical functions: The big oh notation, Euler's summation formula, Dirichlet's asymptotic formula, average order of the divisor functions, average order of the Euler's phi function, average order of the Mobius function, Mangoldt function and its equivalence to Prime number theorem.

UNIT 2: Dirichlet characters: Characters of finite abelian group, the character group, orthogonality relations, Dirichlet characters, sums involving Dirichlet characters. Proof of Dirichlet theorem on primes in arithmetical progressions using sums involving Dirichlet characters. Gauss's sums associated with Dirichlet's character, Dirichlet characters with non vanishing Gauss's sums, Induced moduli and primitive characters, Gauss sum and the quadratic reciprocity law, reciprocity law for quadratic Gauss sums.

UNIT 3: Dirichlet series and Euler product: The half-plane of absolute convergence of a Dirichlet series, Uniqueness theorem, Euler product, analytic properties of Dirichlet series, Mean value formulas for Dirichlet series, An integral formula for the coefficients of Dirichlet series, An integral formula for the partial sums of a Dirichlet series, Perron's formula.

UNIT 4: Partitions: Generating function of partition function $p(n)$, analytic proof of Euler's pentagonal number theorem, analytic proof of Jacobi's triple product identity, recursion formula for partition function, logarithmic differentiation of generating function, recursion formula for sum of divisors function, Hardy-Ramanujan-Rademacher expansion of $p(n)$.

UNIT 5: Asymptotics of Infinite product generating function: Meinardus theorem, asymptotic formula for $p(n)$. Congruence properties of partition functions: Operators related to Hecke operators, Rodseth's theorem for Binary partitions, Ramanujan's conjecture for 5^n, Dyson's theorem.

REFERENCE BOOKS:

1. George E. Andrews, The Theory of Partitions, Addison-Wesley Publishing Company, 1976.

2. Tom M. Apostol, Introduction to Analytic Number theory, Springer International Student Edition,
3. Tom M. Apostol, Modular Functions and Dirichlet series in Number theory, Springer Verlag, 1990.
4. Henry Iwaniec & Emmanuel Kowalski, Analytic Number Theory, American Mathematical Society- Colloquium Publications, Vol. 53, 2013.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering					
K2: Understanding	X		X	X	
K3: Applying					X
K4: Analyzing		X			
K5: Evaluating					
K6: Creating					

MPM 6507 ADVANCED TOPOLOGY 5 Hrs/5 Crs

To make them expertise in the topological concepts and their relevance in different fields and to develop the firm footing on the core subject of Topology.

At the end of the course, students will be able to

i. Summarize quotient spaces and its decomposition.
ii. Explain various concepts in uniform spaces.
iii. Discuss completeness and compactness in uniform spaces.
iv. Discriminate point wise topology and open topology.
v. Identity and demonstrate bitopological spaces

UNIT 1: QUOTIENT SPACES

Identification Topology – Quotient Spaces – Decomposition.

UNIT 2: UNIFORM SPACES

Uniformity - Uniform Continuity – Product Uniformity – Metrization.

UNIT 3: PROXIMITY SPACES

Uniform Subspaces – Completeness in Uniform Spaces – Uniform via Pseudo – Matrices – Compactness in Uniform Spaces – Proximity Spaces.

UNIT 4: FUNCTION SPACES

Point wise Topology – The Compact -Open Topology.

UNIT 5: BITOPOLOGICAL SPACES

Pairwise T_1 and T_2 Spaces – pairwise Regular Spaces – Pairwise Normal spaces.

REFERENCE BOOKS:

1. James R.Munkres, "Topology", Prentice Hall of India, New Delhi, Second Edition (2008).
2. K.C.Rao, "Topology", Narosa Publishing House, New Delhi (2009).

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering	X				
K2: Understanding		X	X		X
K3: Applying					X
K4: Analyzing				X	
K5: Evaluating	X				
K6: Creating					

MPM6509 ADVANCED FLUID DYNAMICS 5 Hrs/5 Crs

To provide the advanced topics in Fluid Dynamics to motivate the students to do research in the field of engineering and industrial sectors.

At the end of the course, students will be able to

i. categorize Newtonian and Non-Newtonian fluids.
ii. demonstrate the governing equations in fluid dynamics.
iii. analyze the characteristics of steady flow over various geometries .
iv. characterize unsteady flow and its physical parameters.
v. discuss boundary flow and the importance of Magnetohydrodynamics.

UNIT 1: GENERAL THEORY OF STRESS AND RATE OF STRAIN

Introduction-Newton's law of viscosity-Newtonian and Non-Newtonian fluids-Body and surface forces-Stress vector and components of stress tensor-State of stress at a point-Symmetry of stress tensor-Transformation of stress components-Plane stress, Principal stresses and principal

directions- Principal stresses, principal directions of stress tensor, principal planes-Nature of strain-Transformation of the rates of strain components-Relation between stress and rates of strain.

UNIT 2: NAVIER-STOKES EQUATIONS AND ENERGY EQUATION

Navier-Stokes equations of motion of a viscous fluid-Equations of motion in cylindrical polar coordinate system and in spherical polar coordinate system-Energy equation-Equation of state for perfect fluid-Diffusion of vorticity and Dissipation of energy-Vorticity equation-Diffusion of a vortex filament-Dimensional analysis-Technique of dimensional analysis-Model analysis and dynamic similarity, Reynold's number-Some useful dimensionless numbers-Some dimensionless coefficients employed in the study of flow of viscous fluids.

UNIT 3: LAMINAR STEADY FLOW OF VISCOUS INCOMPRESSIBLE FLUIDS

Limitations and some exact solutions of Navier-Stokes equations-Steady flow between two parallel planes-Plane Couette flow-Plane Poiseuille flow-Theory of lubrication-Hagen-Poiseuille flow-Laminar steady flow between two coaxial circular cylinders-Laminar steady flow of incompressible viscous fluids in tubes of cross-section other than circular-Laminar floe between two concentric rotating cylinders-Couette flow-Steady motion of viscous fluid due to slowly rotating sphere-Steady flow of viscous incompressible fluid between two porous plates.

UNIT 4: LAMINAR UNSTEADY FLOW OF VISCOUS INCOMPRESSIBLE FLUIDS

Unsteady flow of viscous incompressible fluid over a suddenly accelerated flat plate-Unsteady flow of viscous incompressible fluid between two parallel plates-Unsteady flow over a viscous incompressible fluid over an oscillating plate-Slow motion of a sphere in an incompressible viscous fluid-Flow in convergent and divergent channels- small Reynold's number flows-Flow past a sphere- Flow past a circular cylinder.

UNIT 5: MAGNETOHYDRODYNAMICS & INTODUCTION TO BOUNDARY LAYER THEORY

Nature of Magnetohydrodynamics-Maxwell's electromagnetic field equations: Medium at rest and Medium in motion-Equation of motion of a conducting fluid-Rate of flow of charge-Simplification of electromagnetic field equations-Magnetic Reynold's number-Alfen's theorem-Magnetic body force-Ferraro's law of isorotation-Laminar flow of a viscous conducting liquid between parallel walls in a transverse magnetic field- Introduction to Boundary layer theory-Prandtl's boundary layer theory and its importance –Some basic definitions-Boundary layer equations in 2D flow-Boundary layer flow over a flat plate.

REFERENCE BOOKS:

1. M.D.Raisinghania, **Fluid Dynamics with complete Hydrodynamics and Boundary layer theory**,2006,S.Chand &Company Ltd
2. F.Chorlton, **Fluid Dynamics**,2004,CBS Publishers and Distributors.
3. Goyal & Gupta, **Fluid Dynamics**, 2012, Pragati Prakashan Publishers.
4. D.J. Acheson, **Elementary Fluid Dynamics**, 1989, Clarendon Press. Oxford.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering					
K2: Understanding	X	X		X	X
K3: Applying		X			X
K4: Analyzing	X		X		
K5: Evaluating					
K6: Creating					

MPM 6511 DIFFERENTIAL EQUATIONS 5 Hrs/5 Crs

This course deals with the concepts of differential equation and its applications in various physical problems. This course will motivate the students to do research in the field of mathematics.

At the end of the course, students will be able to

i. demonstrate existence and uniqueness of initial value problems.
ii. explain two dimensional autonomous systems and phase space analysis.
iii. analyze the asymptotic behaviour .
iv. discuss the existence of solution using perron's method.
v. identify and discuss heat and wave equations.

(ODE)

UNIT 1: Existence and Uniqueness of Initial Value Problems: Picard's and Peano's theorems, Gronwall's inequality, continuation of solutions and maximal interval of existence, continuous dependence.

UNIT 2: Two Dimensional Autonomous systems and Phase space analysis: critical points, proper and improper nodes, spiral points and saddle points.

UNIT 3: Asymptotic Behavior: stability (linearized stability and Lyapunov methods).

(PDE)

UNIT 4: Laplace equation: mean value property, weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, existence of solution using perron's method.

UNIT 5: Heat equation: initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results. Wave equation: uniqueness, D'Alembert's method, method of spherical means and Duhamel's principle.

REFERENCE BOOKS:

1. M. Hirsch, S.smale and R.Deveney, Differential Equations, Dynamical systems and introduction to Chaos, Academic Press, 2004.

2. L.Perko, Differential Equations and Dynamical Systems, Texts in Applied Mathematics, Vol.7, 2nd ed., Springer Verlag, New York, 1998.

3. M. Rama Mohana Rao, Ordinary Differential Equations: Theory and Applications. Affiliated East- West Press Pvt.Ltd, New Delhi, 1980.

4. D.A. Sanchez, Ordinary Differential Equations and Stability theory: An introduction, Dover Publ. Inc., New York, 1968.

5. E. DiBenedetto, Partial Differential Equations, Birkhauser, Boston, 1995.

6. L.C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, Providence, 1998.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering					X
K2: Understanding	X	X		X	X
K3: Applying	X				
K4: Analyzing			X		
K5: Evaluating					
K6: Creating					

MPM 6513 ADVANCED FUNCTIONAL ANALYSIS 5 Hrs/5 Crs

Function analysis is an important area of pure mathematics which has wide range of application in quantum mechanics, theoretical physics, control theory, approximation theory and optimization

techniques. The student will be able to appreciate these advanced mathematical structures and its applications in various fields.

At the end of the course, students will be able to

i. demonstrate contraction mapping theorem and its applications.
ii. explain approximation theorems and its consequences.
iii. discuss the structural specialty of inner product space as a special case of Banach spaces.
iv. outline the spectral theory.
v. categorize various linear mappings.

UNIT 1: Contraction mapping theorem and its applications to differential equation, integral equation and system of linear equations. Equicontinuity, Arzla-Ascoli theorem and its application to differential equations.

UNIT 2: Weierstrass's Approximation Theorem, Stone-Weierstrass's Approximation Theorem. Semicontinuity and its applications to Arclength.

UNIT 3: Definition of normed and Banach algebras with identity. Haar measure. Regular points and spectrum. Compactness of spectrum. Resolvent function and its analyticity in the set of regular points. Gelfand's theorem about isomorphism between Banach algebras and complex numbers.

UNIT 4: Spectral radius and the spectral mapping theorem for polynomial Ideals and Maximal ideals in commutative Banach algebras with identity. The set C(M) of complex functions on the set M of maximal ideals in a Banach algebra. Gelfand representation for algebras with identity.

UNIT 5: Bilinear Mappings, Bounded bilinear mappings, sesquilinear mappings, Hermitian form, bounded sesquilinear mappings, bounded sesquilinear forms in Hilbert space.

REFERENCE BOOKS:

1. Bachman, G. and Lawrerie Narici, Functional Analysis, Academic Press.
2. Goffman, C. and G. Pedrick, First Course in Functional Analysis.
3. Berberian, S.K., Introduction to Hilbert Spaces, (Chelsea Publishing Co.N.Y.).
4. Babu Ram, Metric Spaces, Vinayaka Publications, New Delhi.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering				X	
K2: Understanding	X	X	X		

K3: Applying	X				
K4: Analyzing					X
K5: Evaluating				X	
K6: Creating					

MPM 6515 STATISTICAL INFERENCE & STOCHASTIC PROCESS 5 Hrs/5 Crs

The objective of this course is to develop statistical research on interpretation of data with mathematical rigorous treatment. This course intends to develop statistical inferences.

At the end of the course, students will be able to

i. compute maximum likelihood estimator and discuss its properties.
ii. Discuss Neyman pearson fundamental lemma for various distributions and analyze two sided hypothesis.
iii. Demonstrate unbiasedness and various invariant tests.
iv. Explain the concept of stochastic process and classify states and chains
v. Identify and analyze Markov and Poisson process.

UNIT 1 : Statistical inference: Sufficient statistics – sufficiency and completeness – sufficiency and variance . MLE – properties.

UNIT 2: Neyman – Pearson fundamental lemma – distribution with monotone likelihood ratios, confidence bounds. Two-sided hypotheses – tests for parameters in a Normal distribution.

UNIT 3: Unbiasedness: application to one parameter exponential family – similarity and completeness. Invariant tests: Symmetry and invariance – maximal invariance – most powerful invariant tests- Unbiasedness and invariance.

UNIT 4: Introduction to stochastic Process: Basic ideas and definition – classification of stochastic process. Markov chain: Introduction and examples – Two-state Markov chain, classification of state limiting probabilities.

UNIT 5: Markov process – simple Markov process – Poisson process – pure-birth process. Birth and death process – application to queues.

REFERENCE BOOKS:

1. Lehman E.L: Theory of point estimation, springer, 1988
2. Lehman E.L : Testing Statistical Hypothesis, John Wiley & sons, 1986

3. Medhi,J : Stochastic process. Wiley Eastern, 1983
4. Srinivasan,S.K & K.M.Mehata: Stochastic Process, Tata McGraw Hill, 1988.

Bloom's Taxonomy	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
K1: Remembering					
K2: Understanding	X	X	X	X	X
K3: Applying			X		
K4: Analyzing					X
K5: Evaluating	X				
K6: Creating					

MPM 6800 DISSERTATION 18 Crs

The aim of this course is to train the students in literature collection and to gain experience for research. Students are encouraged to take it as a challenge, so that the result of the project shall be approved for publication in leading scientific journals.

At the end of the course, students will be able to

i. understand need and scope of research.
ii. enhance their communication skill through meticulous interactions.
iii. use the mathematical techniques for solving real time issues.
iv. compile and write dissertation based on their experiences as a researcher.
v. use the modern gadgets and exploit the digital data for an enhanced accuracy and reliability.

Guidelines & Instructions:

- The project work for M.Phil Mathematics Program is to be undertaken during II semester.
- The candidates have to review the research proposal and finalize the title of the project with the help of the supervisor.
- The student shall be instructed to meet the supervisor periodically for evaluating the progress.

- The Project work for M.Phil Mathematics shall be pursued for a minimum of 45 days during the final semester.
- The scholar must attend at least one state/national/international workshop/seminar during the project period.
- The scholar shall present at least one research paper in a conference/seminar before submission of the dissertation.
- The deadline for submission of dissertation is the last working day of the semester.
- If the candidate is not completing the project in the current semester, then the candidate can undertake the project in the subsequent semester.

Evaluation:

The Project Work for M.Phil. Mathematics shall be done independently by the student in the respective semesters and marks shall be allotted as per the weightage given in tabular column. There shall be two reviews (each 50 Marks) during the project period by the supervisor. The student shall make presentation on the progress made by him / her before the supervisor. The total marks obtained in the two reviews will be 100 Marks. The supervisor will assess for 200 marks (Including the regular discussion, attendance and participation in Seminars/ Workshops/Conferences). At Viva-Voce examination, external shall provide maximum of 100 marks for dissertation and 100 marks for presentation.

<table>
<tr><th colspan="2">Internal Assessment
(50 Marks)</th><th colspan="3">Viva-Voce Examination
(50 Marks)</th></tr>
<tr><th rowspan="2">Review -I</th><th rowspan="2">Review -II</th><th>Internal
(Guide)</th><th colspan="2">External</th></tr>
<tr><th rowspan="2">100</th><th>Presentation</th><th>Dissertation</th></tr>
<tr><td>50</td><td>50</td><td>100</td><td>100</td></tr>
</table>