

M. Sc. Mathematics
Semester - IV

MAT-401
Inner Product Spaces and
Measure Theory

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Hilbert Spaces: Inner product spaces, Hilbert spaces, Schwarz's inequality, Hilbert space as normed linear space, Convex sets in Hilbert spaces, Projection theorem.

Section-II

Orthonormal sets, Separability, Total Orthonormal sets, Bessel's inequality, Parseval's identity. Conjugate of a Hilbert space, Riesz representation theorem in Hilbert spaces, Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert space, Self-adjoint operators, Positive operators, Product of Positive Operators.

Section-III

Projection operators, Product of Projections, Sum and Difference of Projections, Normal and unitary operators, Projections on Hilbert space, Spectral theorem on finite dimensional space. Measure space, Generalized Fatou's lemma, Measure and outer measure, Extension of a measure, Caratheodory extension theorem.

Section-IV

Signed measure, Hahn decomposition theorem, Jordan decomposition theorem, Mutually signed measure, Radon-Nikodym theorem, Lebesgue decomposition, Lebesgue-Stieltjes integral, Product measures, Fubini's theorem, Baire sets, Baire measure, Continuous functions with compact support.

Books recommended

1. George F. Simmons, Introduction to Topology and Modern Analysis, McGrawHill Book Company, 1963
2. H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4th Edition, 1993.
3. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley (1978).
4. S.K. Berberian, Measure and Integration, Chelsea Publishing Company, New York, 1965.
5. K.C. Rao, Functional Analysis, Narosa Publishing House, Second edition, 2006.

M. Sc. Mathematics
Semester - IV

MAT-402
Classical Mechanics

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Moments and products of inertia, The theorems of parallel and perpendicular axes, Angular momentum of a rigid body about a fixed point and about fixed axes, Principal axes and principal moments of inertia of a rigid body, Kinetic energy of a rigid body rotating about a fixed point, Momental ellipsoid and equimomental systems, Coplanar mass distributions, General motion of a rigid body. (Relevant topics from the book of Chorlton).

Section-II

Free and constrained systems, Constraints and their classification, Holonomic and non-holonomic systems, Scleronomic and Rheonomic systems, Possible and Virtual Displacements, Possible velocities and possible accelerations, Ideal constraints, The General equation of dynamics, Lagrange's equations of the first kind. The Principle of Virtual Displacements, D' Alembert's Principle.

Independent coordinates and Generalized forces, Lagrange's equations of the second kind in independent coordinates, Generalized velocities and accelerations, Kinetic energy as a function of generalized velocities, Uniqueness of solution, Theorem on Variation of total energy, Potential, Gyroscopic and Dissipative Forces.

Section-III

Lagrange's equations for Potential Forces, The Generalized Potential, Lagrangian and Hamiltonian variables, Donkin's theorem, Hamilton canonical equations, Routh variables and Routh function, Routh's equations, Cyclic or Ignorable coordinates, Poisson Bracket and their simple properties, Poisson identity, Jacobi-Poisson theorem.

Hamilton's principle, Poincare-Carton Integral Invariant, Generalized Conservative Systems, Whittaker's equations, Jacobi's equations, Lagrangian action and the principle of least action. The Universal Integral Invariant of Poincare, Lee Hwa-Chung's Theorem (Statement only).

Section-IV

Canonical transformations, Necessary and sufficient condition for a transformation to be canonical, Univalent canonical transformations, Free canonical transformations, Hamilton-Jacobi equation, Jacobi's theorem, Method of separation of variables in HJ equation.

The Lagrange Brackets, Necessary and sufficient conditions for the canonical character of a transformation in terms of Lagrange Brackets, The Simplicial Nature of the Jacobian Matrix of a canonical transformation, Conditions of canonicity of a transformation in terms of Poisson Brackets, Invariance of the Poisson Brackets in a canonical transformation.

Books recommended

1. F. Chorlton, Textbook of Dynamics, CBS Publishers, New Delhi.
2. F. Gantmacher, Lectures in Analytical Mechanics, MIR Publishers, Moscow, 1975.
3. N.C. Rana and P.S. Joag, Classical Mechanics, Tata McGraw- Hill, New Delhi, 1991.
4. P.V. Panat, Classical Mechanics, Narosa Publishing House, New Delhi, 2005.
5. Louis N. Hand and Janet D. Finch, Analytical Mechanics, CUP, 1998.
6. K. Sankra Rao, Classical Mechanics, Prentice Hall of India, 2005.
7. M.R. Speigel, Theoretical Mechanics, Schaum Outline Series.

M. Sc. Mathematics
Semester - IV

MAT-403
Viscous Fluid Dynamics

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Vorticity in two dimensions, Circular and rectilinear vortices, Vortex doublet, Images, Motion due to vortices, Single and double infinite rows of vortices. Karman vortex street. Wave motion in a Gas. Speed of sound in a gas. Equation of motion of a Gas. Subsonic, sonic and supersonic flows. Isentropic gas flow, Flow through a nozzle.

Section-II

Stress components in a real fluid. Relation between Cartesian components of stress. Translational motion of fluid element. Rates of strain. Transformation of rates of strains. Relation between stresses and rates of strain. The co-efficient of viscosity and laminar flow. Newtonian and non-Newtonian fluids. Navier-Stokes equations of motion. Equations of motion in cylindrical and spherical polar co-ordinates. Equation of energy. Diffusion of vorticity. Energy dissipation due to viscosity. Equation of state.

Section-III

Plane Poiseuille and Couette flows between two parallel plates. Theory of lubrication. Hagen Poiseuille flow. Steady flow between co-axial circular cylinders and concentric rotating cylinders. Flow through tubes of uniform elliptic and equilateral triangular cross-section. Unsteady flow over a flat plate. Steady flow past a fixed sphere. Flow in convergent and divergent channels.

Section-IV

Dynamical similarity. Inspection analysis. Non-dimensional numbers. Dimensional analysis. Buckingham π -theorem and its application. Physical importance of non-dimensional parameters. Prandtl boundary layer. Boundary layer equation in two-dimensions. The boundary layer on a flat plate (Blasius solution). Characteristic boundary layer parameters. Karman integral conditions. Karman-Pohlhausen method.

Books recommended

1. W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1988.
2. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
3. O'Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.
4. O'Neill, M.E. and Chorlton, F., Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.
5. S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976.
6. H. Schlichting, Boundary-Layer Theory, McGraw Hill Book Company, New York, 1979.
7. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
8. G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

M. Sc. Mathematics
Semester - IV

MAT-404
Computing Lab-II (MATLAB)

Max. Marks : 50
Time: 3 hrs



Note: -

- (A) Each candidate will be provided a question paper of four questions and will be required to attempt two questions. The candidate will first the program in MATLAB of the questions in the answer-book and then run the same on the computer, and then finally add the print-outs of these programs in the answer-book. This work will consist of 30 marks, 15 marks for each question.
- (B) The practical file of each student will be checked and Viva-Voce examination based upon the practical file and the theory will be jointly conducted by external and internal examiners. This part of the practical examination shall be of 20 marks.

M. Sc. Mathematics
Semester - IV

MAT-407
Advanced Complex Analysis

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



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Section-I

Integral Functions, Factorization of an integral function, Weierstrass primary factors, Weierstrass factorization theorem, Gamma function and its properties, Stirling formula, Integral version of gamma function, Riemann Zeta function, Riemann functional equation, Mittag-Leffler theorem, Runge theorem(Statement only).

Section-II

Analytic Continuation, Natural Boundary, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation, Schwarz Reflection principle, Germ of an analytic function. Monodromy theorem and its consequences, Harmonic functions on a disk, Poisson kernel, The Dirichlet problem for a unit disc.

Section-III

Harnack inequality, Harnack theorem, Dirichlet region, Green function, Canonical product, Jensen formula, Poisson-Jensen formula, Hadamard three circles theorem, Growth and order of an entire function, An estimate of number of zeros, Exponent of convergence, Borel theorem, Hadamard factorization theorem.

Section-IV

The range of an analytic function, Bloch theorem, Schottky theorem, Little Picard theorem, Montel Caratheodory theorem, Great Picard theorem, Univalent functions, Bieberbach conjecture (State- ment only) and the “1/4 theorem”

Books recommended

1. H. A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2011.
3. J. B. Conway, Functions of one complex variable, Springer-Verlag, International Student Edition, Narosa Publishing House, 2002.
4. Liang-shin Hann and Bernard E., Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
5. E. T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London.
6. E. C. Titchmarsh, The Theory of Functions, Oxford University Press, London.
7. Mark J. Ablowitz and A.S. Fokas, Complex Variables: Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.
8. Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company.
9. H.S. Kasana, Complex Variable Theory and Applications, PHI Learning Private Ltd, 2011.

M. Sc. Mathematics
Semester - IV

MAT-408
Graph Theory

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Definition and types of graphs, Walks, Paths and Circuits, Connected and Disconnected graphs, Applications of graphs, operations on Graphs, Graph Representation, Isomorphism of Graphs.

Section-II

Eulerian and Hamiltonian paths, Shortest Path in a Weighted Graph, The Travelling Sales person Problem, Planar Graphs, Detection of Planarity and Kuratowski Theorem, Graph Colouring.

Section-III

Directed Graphs, Trees, Tree Terminology, Rooted Labeled Trees, Prefix Code, Binary Search Tree, Tree Traversal.

Section-IV

Spanning Trees and Cut Sets, Minimum Spanning Trees, Kruskal Algorithm, Prim Algorithm, Decision Trees, Sorting Methods.

Books recommended

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, PHIPvt.Ltd, 2004.
2. F. Harary: Graph Theory, Addition Wesley, 1969.
3. G. Chartrand and P. Zhang. Introduction to Graph Theory, Tata McGraw-Hill, 2006.
4. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition, 1999.
5. Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co, New York, 2007.
6. John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition, 2005.
7. C. L. Liu and D.P. Mohapatra, Elements of Discrete Mathematics- A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

M. Sc. Mathematics
Semester - IV

MAT-409
Applied Solid Mechanics

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Two dimensional problems: Plane strain deformation, State of plane stress, Generalized plane stress, Airy stress function for plane strain problems, Solutions of a two-dimensional biharmonic equation using Fourier transform as well as in terms of two analytic functions, Expressions for stresses and displacements in terms of complex potentials, Deformation of a thick-walled elastic tube under external and internal pressures.

Section-II

Torsion of Beams: Torsion of a circular cylindrical beam, Torsional rigidity, Torsion and stress functions, Lines of shearing stress, Torsion of a beam of arbitrary cross-section and its special cases for circular, elliptic and equilateral triangular cross-sections, Circular grooves in a circular beam. Extension of Beams: Extension of beams by longitudinal forces, Beams stretched by its own weight.

Section-III

Bending of Beams: Bending of beams by terminal couples, Bending of a beam by transverse load at the centroid of the end section along a principal axis. Variational Methods: One-dimensional Ritz method, Two - dimensional Ritz method, Galerkin method, Application to torsion of beams. (Relevant topics from the Sokolnikof book).

Section-IV

Waves: Simple harmonic progressive waves, Plane waves, Progressive type solutions in cartesian coordinates, Stationary type solutions in Cartesian coordinates.
Elastic Waves: Propagation of waves in an unbounded elastic isotropic media, P-waves, S - waves, Wave propagation in two-dimensions, P-SV waves and SH waves.

Books recommended

1. I. S. Sokolnikof, Mathematical theory of Elasticity, Tata McGraw Hill Publishing company Ltd. New Delhi, 1977.
2. Teodar M. Atanackovic and Ardesliv Guran, Theory of Elasticity for Scientists and Engineers, Birkhausev, Boston, 2000.
3. A. K. Mal and S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991.
4. C. A. Coluson, Waves.
5. A. S. Saada, Elasticity-Theory and Applications, Pergamon Press, New York, 1973.
6. D. S. Chandersekharian and L. Debnath, Continuum Mechanics, Academic Press.

M. Sc. Mathematics
Semester - IV

MAT-410
Bio-Mechanics

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Newton equations of motion, Mathematical modeling, Continuum approach, Segmental movement and vibrations, Lagrange equations, Normal modes of vibration, Decoupling of equations of motion. Flow around an airfoil, Flow around bluff bodies, Steady state aeroelastic problems, Transient fluid dynamics forces due to unsteady motion, Flutter.

Section-II

Kutta-Joukowski theorem, Circulation and vorticity in the wake, Vortex system associated with a finite wing in nonsteady motion, Thin wing in steady flow.

Blood flow in heart, lungs, arteries, and veins, Field equations and boundary conditions, Pulsatile flow in arteries, Progressive waves superposed on a steady flow, Reflection and transmission of waves at junctions.

Section-III

Velocity profile of a steady flow in a tube, Steady laminar flow in an elastic tube, Velocity profile of Pulsatile flow, The Reynolds number, Stokes number, and Womersley number, Systematic blood pressure, Flow in collapsible tubes.

Micro- and macro-circulation Rheological properties of blood, Pulmonary capillary blood flow, Respiratory gas flow, Interaction between convection and diffusion, Dynamics of the ventilation system.

Section-IV

Laws of thermodynamics, Gibbs and Gibbs Duhem equations, Chemical potential, Entropy in a system with heat and mass transfer, Diffusion, Filtration, and fluid movement in interstitial space in thermodynamic view, Diffusion from molecular point of view.

Mass transport in capillaries, Tissues, Interstitial space, Lymphatics, Indicator dilution method, and peristalsis, Tracer motion in a model of pulmonary micro-circulation.

Books recommended

1. Y.C. Fung, Biomechanics: Motion, Flow, Stress and Growth, Springer-Verlag, New York Inc., 1990.

M. Sc. Mathematics
Semester - IV

MAT-411
Algebraic Number Theory

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

Algebraic Number and Integers : Gaussian integers and its properties, Primes and fundamental theorem in the ring of Gaussian integers, Integers and fundamental theorem in $\mathbb{Q}(\omega)$ where $\omega^3 = 1$, Algebraic fields, Primitive polynomials, The general quadratic field $\mathbb{Q}(\sqrt{m})$, Units of $\mathbb{Q}(\sqrt{2})$, Fields in which fundamental theorem is false, Real and complex Euclidean fields, Fermat theorem in the ring of Gaussian integers, Primes of $\mathbb{Q}(\sqrt{2})$ and $\mathbb{Q}(\sqrt{5})$.

Section-II

Countability of set of algebraic numbers, Liouville theorem and generalizations, Transcendental numbers, Algebraic number fields, Liouville theorem of primitive elements, Ring of algebraic integers, Theorem of primitive elements.

Section-III

Norm and trace of an algebraic number, Non degeneracy of bilinear pairing, Existence of an integral basis, Discriminant of an algebraic number field, Ideals in the ring of algebraic integers, Explicit construction of integral basis, Sign of the discriminant, Cyclotomic fields, Calculation for quadratic and cubic cases.

Section-IV

Integral closure, Noetherian ring, Characterizing Dedekind domains, Fractional ideals and unique factorization, G.C.D. and L.C.M. of ideals, Chinese remainder theorem, Dedekind theorem, Ramified and unramified extensions, Different of an algebraic number field, Factorization in the ring of algebraic integers.

Books recommended

1. Esmonde and M RamMurty, Problems in Algebraic Number Theory, GTM Vol.190, SpringerVerlag, 1999.
2. G.H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers
3. W.J. Leveque, Topics in Number Theory Vols. I, III Addition Wesley.
4. H. Pollard, The Theory of Algebraic Number, Carus Monograph No. 9, Mathematical Association of America.
5. P. Riebenboim, Algebraic Numbers Wiley Inter-science.
6. E. Weiss, Algebraic Number Theory, McGraw Hill.

M. Sc. Mathematics
Semester - IV

MAT-412
Algebraic Coding Theory

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



Note: The question paper will consist of five Sections. Each of the sections I to IV will contain two questions of 16 marks each and the students shall be asked to attempt one question from each. Section-V shall be compulsory and will contain eight short answer type questions of 2 marks each without any internal choice covering the entire syllabus.

Section-I

The communication channel, The coding problem, Types of codes, Block codes, Types of codes such as repetition codes, Parity check codes and their error-detection and correction capabilities. Hamming metric, Relationship of error detection/correction with hamming distance, Maximum likelihood decoding procedure, Decoding by syndrome decoding and Coset leaders, Standard array.

Section-II

Linear codes (Binary and non binary), Minimum distance, Dimension, Modular representation of linear codes, Description of linear codes by matrices, Polynomial codes, Generator and parity check polynomials and matrices.

Section-III

Dual codes, Self duality, Weight distribution of dual of binary linear codes, Macwilliam identity (binary case) extending, Expurgating and augmenting a code, Lee metric, Convolutional codes, Description using matrices and polynomials, Encoding using (4,3,2) encoder.

Section-IV

Hamming codes (Binary and non-binary) and their properties, Perfect and quasi-perfect codes. Go-lay codes as perfect codes, Bounds on minimum distance for block codes, Plotkin bound, Hamming sphere.

Books recommended

1. Raymond Hill, A First Course in Coding Theory, Oxford University Press, 1986.
2. Man Young Rhee, Error Correcting Coding Theory, McGraw Hill Inc., 1989.
3. W. W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes. M.I.T. Press, Cambridge Massachusetts, 1972.
4. E. R. Berlekamp, Algebraic Coding Theory, McGraw Hill Inc., 1968.
5. F. J. Macwilliams and N.J.A. Sloane, Theory of Error Correcting Codes, North-Holand Publishing Company.
6. J. H. Van Lint, Introduction to Coding Theory, Graduate Texts in Mathematics, 86, Springer, 1998.
7. L. R. Vermani, Elements of Algebraic Coding Theory, Chapman and Hall, 1996.

M. Sc. Mathematics
Semester - IV

MAT-413
Bio-Fluid Dynamics

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



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Section-I

Basic concepts of fluid dynamics. Viscosity. Reynold transport theorem, Rates of change of material integrals, Continuity equation, Navier-Stokes equations of motion, Simplification of basic equations. Reynolds number of flows. The cardiovascular system. The circulatory system. Systemic and pulmonary circulations. The circulation in the heart. Diseases related to circulation.

Section-II

Blood composition. Structure of blood. Viscosity of blood. Yield stress of blood. Blood vessel structure. Diseases related to obstruction of blood flow. Flow in pipes and ducts. Developing and fully developed flow. Special characteristics of blood flow. Poiseuille flow and its consequence. Applications of Poiseuille law for the study of blood flow.

Section-III

Pulsatile flow in circular rigid tube and its quantitative aspects. The pulse wave. Mones-Korteweg expression for wave velocity in an inviscid fluid-filled elastic cylindrical tube and its applications in the cardiovascular system. Wave propagation accounting for viscosity and its application to cardiac output determination. Blood flow through artery with mild stenosis, Expressions for pressure drop across the stenosis and across the whole length of artery. Shear stress on stenosis surface.

Section-IV

Non-Newtonian fluids and their classification. Laminar flow of non-Newtonian fluids. Power-law model, Herschel-Bulkley model, Casson model. Flow in the renal tubule. Solutions when radial velocity at the wall decreases (i) linearly with z (ii) exponentially with z . Peristaltic flows. Peristaltic motion in a channel, Characteristic dimensionless parameters. Long- wavelength analysis.

Books recommended

1. Jagan N. Mazumdar; Biofluid Mechanics, World Scientific Pub.
2. J. N. Kapur; Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt.Ltd.
3. T. J. Pedley; The Fluid Mechanics of Large Blood Vessels, Cambridge Uni. Press, 1980.
4. M. Stanley; Transport Phenomenon in Cardiovascular System, 1972.
5. O'Neill, M. E. and Chorlton, F., Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.
6. J. L. Bansal, Viscous Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 2000.

M. Sc. Mathematics
Semester - IV

MAT-414
Fractional Calculus

Max. Marks : 100
Theory Marks: 80
Internal Marks : 20
Time: 3 hrs



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Section-I

Gamma Function: Definition of the Gamma function, Some properties of the Gamma function, Limit Representation of the Gamma function, Beta Function, Contour Integral Representation,

Contour Integral Representation of $\Gamma(z)$

Mittag-Leffler Function: Definition and Relation to some other functions, The Laplace transformation of the Mittag-Leffler Function in two parameters, Derivative of the Mittag-Leffler Function, Differential Equations for the Mittag-Leffler Function, Summation Formulas, Integration of the Mittag-Leffler function.

Section-II

The name of the Game, Grunwald Letnikov Fractional derivatives: Unification of Integer-order Derivatives and integrals, Integrals of Arbitrary Order, Derivatives of Arbitrary order, Fractional Derivative of t^α , Composition with integer-order Derivatives, Composition with Fractional Derivatives Riemann Liouville Fractional Derivatives: Unification of integral-order Derivatives and Integrals, Integrals of Arbitrary Order, Derivatives of Arbitrary Order, Fractional Derivative of $(t - a)^\beta$, Composition with Integer-Order Derivatives, Composition with Fractional Derivatives, Link of the Grunwald-letnikov Approach,

Section-III

Some Other Approaches: Caputo's Fractional Derivative, Generalized Functions Approach, Sequential Fractional Derivatives, Left and Right Fractional Derivatives.

Properties of fractional Derivatives: Linearity, The Leibniz Rule for Fractional Derivatives, Fractional Derivative of a Composite Function, Riemann Liouville fractional Differentiation of an Integral depending on a Parameter, Behaviour near the Lower terminal, Behaviour far from the Lower terminal.

Laplace transforms of Fractional Derivatives: Basic Facts on the Laplace transform, Laplace Transform of the Riemann-Liouville Fractional Derivatives, Laplace Transform of the Caputo Derivative, Laplace Transform of the Grunwald-Letnikov Fractional Derivative, Laplace transform of the Miller Ross Sequential Fractional Derivative

Section-IV

Fourier transforms of Fractional Derivatives: Basic Facts on the Fourier transform, Fourier Transform of Fractional Integrals, Fourier Transform of Fractional Derivatives.

Linear Fractional Differential Equations, Fractional Differential equation of the General Form, Existence and Uniqueness theorem as a Method of Solution, Dependence of a Solution on Initial Conditions.

Standard Fractional Differential Equations: Ordinary Linear Fractional Differential Equations, Partial Linear Fractional Differential Equations.

Sequential Fractional Differential Equations: Ordinary Linear Fractional Differential Equations, Partial Linear Fractional Differential Equations.

Books recommended

1. K.S. Miller and B. Rose, An Introduction to the Fractional Calculus and Fractional Differential Equations, John Wiley & sons Inc., New York, 1993.
2. Igor Podlubny, Fractional Differential Equations, Academic Press.
3. OLDHAM, Keith B., SPNIER, Jerome. The Fractional Calculus. London: Academic Press 1974. 225p.