

Department of Mathematics and Statistics
School of Physical and Biological Sciences
Faculty of Science, Technology and Architecture

M. Sc. Mathematics

Year	FIRST SEMESTER						SECOND SEMESTER					
	Course Code	Course Name	L	T	P	C	Course Code	Course Name	L	T	P	C
I	MAS6111	Advanced Linear Algebra	3	1	0	4	MAS6201	Partial Differential Equations	3	1	0	4
	MAS6112	Mathematical Analysis	3	1	0	4	MAS6202	Optimization Theory and Techniques	3	1	0	4
	MAS6113	Differential Equations	2	1	0	3	MAS6203	Functional Analysis	3	1	0	4
	MAS6114	Advanced Complex Analysis	3	1	0	4	MAS6204	Measure theory & Integration	3	1	0	4
	MAS6116	Topology-I	2	1	0	3	MAS6205	Research Methodology & Technical Writing	3	1	0	3
	MAS6118	Dynamics of a Rigid Body	2	1	0	3	MAS6230	Lab on Optimization Theory and Techniques	0	0	2	1
							MAS6270	Seminar	0	0	0	1
			15	6	0	21			15	5	2	21
	Total Contact Hours (L + T + P)		21			Total Contact Hours (L + T + P)		22				
II	THIRD SEMESTER						FOURTH SEMESTER					
	MAS7101	Fluid Dynamics	3	1	0	4	MAS7270	Project	0	0	0	16
	MAS7102	Special Functions	3	1	0	4						
	MAS7103	Integral Equations and Calculus of Variations	3	1	0	4						
	MAS7104	Theory of Field Extensions	3	1	0	4						
	*****	DSE – I	2	1	0	3						
	*****	DSE – II	2	1	0	3						
		15	6	0	22			0	0	0	16	
	Total Contact Hours (L + T + P)		21			Total Contact Hours (L + T + P)		0				

Discipline Specific Elective (DSE)	
<u>DSE-I</u> 1. MAS7140: Mechanics of Solids 2. MAS7141: Stochastic Process 3. MAS7142: Fuzzy Sets & Their Applications	<u>DSE-II</u> 1. MAS7143: Topology-II 2. MAS7144: Linear Models 3. MAS7145: Computational Fluid Dynamics 4. MAS7146: Mathematical Statistics

MAS6111: ADVANCED LINEAR ALGEBRA [3 1 0 4]

Linear Transformations: Vector space, basis, dimension and related properties, algebra of linear transformations, vector space of linear transformations $L(U,V)$, dimension of space of linear transformations, linear functional, dual basis, computing of a dual basis, dual vector spaces, annihilator, second dual space, dual transformations. Elementary Canonical forms: Characteristics value, annihilating polynomials, invariant subspaces, simultaneous triangularization and diagonalization. Direct sum decomposition, invariant direct sum, the primary decomposition theorem. Inner-Product Spaces: Normed space, Cauchy Schwartz inequality, Pythagorean theorem, Orthogonal set, Gram-Schmidt orthonormalization process, orthogonal projections, orthogonal complements, Bessel's inequality, Riesz representation theorem, functional and adjoints, related theorems. Bilinear forms, Symmetric bilinear forms, skew symmetric bilinear forms, Group preserving bilinear forms.

References:

1. K. B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd, New Delhi, 2007.
2. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, First course in Linear Algebra, New Age International Ltd, 2012.
3. K. Hoffman and R. Kunze, Linear Algebra, 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey, 2014.
4. S. Kumaresan, Linear Algebra-A geometric approach, Prentice Hall of India, 2000.
5. R. B. Dash and D. K. Dalai, Fundamentals of Linear Algebra, Himalaya Publishing house, 2008.

MAS6112: MATHEMATICAL ANALYSIS [3 1 0 4]

Riemann-Stieltjes Integral: Introduction, existence and properties, integration and differentiation, fundamental theorem of calculus, integration of vector-valued functions, rectifiable curves; Sequence and Series of Functions: Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weierstrass M test, Abel and Dirichlet tests for uniform convergence, uniform convergence and continuity, uniform convergence and differentiation, Weierstrass approximation theorem, power series, uniform convergence and uniqueness theorem, Abel theorem, Tauber theorem; Calculus of Functions of Several Variables: Continuity, Partial and directional derivatives, Differentiability, Chain rule, Taylor theorem, inverse function theorem, implicit functions theorem, Maxima and Minima. Lagrange multipliers method

References:

1. W. Rudin, Principles of Mathematical Analysis, 3rd edition, McGraw-Hill, Kogakusha, 2017.
2. H.L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th edition, New York, 2009.
3. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi, 2012.
4. T. M. Apostol, Mathematical Analysis, Addison-Wesley Publishing Company, 2008.
5. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.

MAS6113: DIFFERENTIAL EQUATIONS [2 1 0 3]

Preliminaries: ε -approximate solution, Cauchy-Euler construction of an ε -approximate solution of an initial value problem, Picard's Theorem and Peano's Theorem. Equicontinuous family of functions; Basic Theorems: Ascoli-Arzelà lemma, Cauchy-Peano existence theorem, Lipschitz condition, Picard-Lindelöf existence and uniqueness theorem for $dy/dt=f(t,y)$; Dependence of Solutions on Initial Conditions: Linear systems, Matrix method first order system of linear differential equations, Critical points, Proper and improper Nodes, Spiral Points and saddle points; Fundamental Set of Solutions: Wronskian, basic theory of the homogeneous linear system, Abel-Liouville formula. Sturm theory, selfadjoint equations of the second order, Abel formula, Sturm separation theorem, Sturm fundamental comparison theorem, nonlinear differential systems, phase plane, path, critical points. Sturm-Liouville problems, orthogonality of characteristic functions.

References:

1. W.E. Boyce and R.C. DiPrima, Elementary Differential Equations, 9th Ed., John Wiley & Sons, 2008.
2. G.F. Simmons, Differential Equations, Tata McGraw Hill, New Delhi, 2016.
3. E.A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw Hill, 2000.
4. S.L. Ross, Differential Equations, John Wiley and Sons Inc., New York, 2004.
5. W.E. Boyce and R.C. DiPrima, Elementary Differential Equations and Boundary Value Problems, John Wiley and Sons, Inc., New York, 4th edition, 2012

MAS6114: ADVANCED COMPLEX ANALYSIS [3 1 0 4]

The extended complex plane and Stereographic projection, Topology of the complex numbers and calculus of Complex function; Multivalued Complex function- the argument function and the principal branch of the logarithm. Existence of local primitive for a complex differentiable function on discs or convex domains. Uniform limits of holomorphic functions. Cauchy's estimates. Inverse and Open mapping theorems; the local maximum modulus principle. Isolated Casoratti-Weierstrass theorem. Residue theorem with applications to computations of Fourier transforms. Hurwitz's theorem on the limit of a sequence of an injective holomorphic mappings. Holomorphic automorphic automorphisms of the disc. Fractional Linear transformations. Riemann mapping theorem; various equivalent characterizations of simply connected planar domains. Analytic continuation: definition and examples; Schwarz reflection principle. Harmonic functions on a disk, Poisson kernel, Dirichlet problem for a unit disc, Harnack inequality, Harnack theorem, Dirichlet region, Green function, Canonical product, Jensen formula. Holomorphic functions as vector fields and the physical interpretation of Cauchy-Riemann equations. Harmonic functions; harmonic conjugates and connection with holomorphic functions. Poisson integral formula for the disc as a consequence of the Cauchy integral formula.

References:

1. Serge Lang, Complex Analysis, Springer, 2013
2. J. Bruna, J. Cufi, Complex Analysis, Hindustan Book Agency, 2015
3. Gamelin T., Complex Analysis, Springer, 2013
4. Lars V. Ahlfors, Complex Analysis, McGraw Hill Education; Third edition, 2017
5. Elias M. Stein, Rami Shakarchi, Complex Analysis, Volume 2 of Princeton lectures in analysis, Princeton University Press, 2010.
6. Donald E. Marshall, Complex Analysis, Cambridge University Press, 2019.

MAS6116: TOPOLOGY-I [2 1 0 3]

Basic Concepts: Definition and examples of topological spaces, comparison of topologies on a set, intersection and union of topologies on a set, neighborhoods, Interior point and interior of a set, closed set as a complement of an open set, adherent point and limit point of a set, closure of a set, derived set, properties of closure operator, boundary of a set, dense subsets, interior, exterior and boundary operators, alternative methods of defining a topology in terms of neighborhood system and Kuratowski closure operator, relative (induced) topology, base and subbase for a topology, Base for Neighborhood system, continuous functions, open and closed functions, homeomorphism. Connectedness and its characterization; Connected Spaces: connected subsets and their properties, continuity and connectedness, components, locally connected spaces; Compact Spaces : Compact spaces and subsets, compactness in terms of finite intersection property, continuity and compact sets, basic properties of compactness, closeness of compact subset and a continuous map from a compact space into a Hausdorff and its consequence, sequentially and countably compact sets, Local compactness and one

point compactification; Separation Axioms: First countable, second countable and separable spaces, Hereditary and topological property, countability of a collection of disjoint open sets in separable and second countable spaces, Lindelof theorem, T_0 , T_1 , T_2 (Hausdorff) separation axioms, their characterization and basic properties.

References:

1. C.W. Patty, Foundation of Topology, Jones & Bertlett, 2009.
2. Fred H. Croom, Principles of Topology, Cengage Learning, 2009.
3. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1983.
4. J. R. Munkres, Topology, Pearson Education Asia, 2002.
5. K. Chandrasekhara Rao, Topology, Narosa Publishing House Delhi, 2009.
6. K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd, 2006.
7. W.J. Pervin, Foundations of General Topology, Academic Press Inc. New York, 2014.

MAS6118: DYNAMICS OF A RIGID BODY [2 1 0 3]

Moments and Products of inertia; some special cases of moment of inertia, theorem of parallel and perpendicular axis, principal axis, D'Alembert's Principle; Introduction of motion of particle, general equations of motion of a rigid body, motion of centre of inertia and motion relative to centre of inertia, Motion about a fixed axis; finite forces, moment of effective forces about a fixed axis of rotation, angular momentum, Kinetic energy of a rotating body about a fixed line, equation of motion of the body about the axis of rotation, Motion in two dimensions; equation of motion in two dimensions, kinetic energy, moment of momentum, motion of imperfectly rough sphere, Impulsive forces in two dimensions (under finite forces); equation of motion (when forces are impulsive), work done by an impulse, Conservation of moment and energy; principle of conservation of linear momentum (under finite forces), principle of angular momentum (when force are finite), principle of conservation of linear momentum (when force are impulsive), principle of conservation of angular momentum (when forces are impulsive), principle of conservation of energy, Initial motion, Lagrange's equations for a conservative and impulsive forces.

References:

1. M.D. Raishinghamia, Dynamics, S. Chand & Co. New Delhi, 2016.
2. S.L. Loney, Dynamics of a Particle and Rigid body, G. K. Publications, 2016.
3. P.P. Gupta and G.S. Malik, Rigid Body of Dynamics-I, Krishna Prakashan, 2014.
4. S.L Loney, The Elementary on the Dynamics of a Particle and the Rigid Bodies, GK Publications Ltd., 2012.
5. M.Ray and H.S. Sharma, Textbook on Dynamics of Rigid Body, S Chand & Com., 2005.

MAS6201: PARTIAL DIFFERENTIAL EQUATIONS [3 1 0 4]

Curves and surfaces in three dimensions, origin of PDEs, Lagrange's method, orthogonal surfaces, non-linear PDE of first order, Cauchy's method of characteristic, compatible system of first order PDE, Charpit's and Jacobi method, special types of first order PDEs, Cauchy problem for first order PDEs. Origin of second order PDE, linear second order PDE with constant coefficients, linear second order PDE with variable coefficients, characteristic curves of the second order PDE, Monge's method of solution of non-linear PDE of second order, separation of variables in a PDE, solutions of higher order linear PDEs, method of separation of variables for Laplace, heat, wave and diffusion equations, Canonical form and reduction to canonical form, resolution of boundary value problems for diffusion equation, elementary solutions of diffusion equation, separation of variables.

References:

1. N. Sneddon, Elements of Partial Differential Equation, 3rd edition, Dove Publication, 2006.
2. M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand & Sons, 2010.
3. E. T. Copson, Partial Differential Equations, Cambridge University Press, 1995.
4. Evans, L. C. Partial Differential Equations. 2nd edition, The Orient Blackswan, 2014
5. J. R. Buchanan and Z. Shao, A First Course of Partial Differential Equation, World Scientific Publishing, 2017

MAS6202: OPTIMIZATION THEORY AND TECHNIQUES [3 1 0 4]

Unconstrained Optimization: Fibonacci golden section and quadratic interpolation methods for one dimensional problems, steepest descent, conjugate gradient and variable metric methods for multidimensional problems; Nonlinear Programming: Generalized convexity, quasi and 120anach convex functions and their properties, general nonlinear programming problem, difficulties introduced by nonlinearity, Kuhun-Tucker necessary conditions for optimality, insufficiency of K-T conditions, sufficiency conditions for optimality, solution of simple NLPP using K-T conditions; Quadratic Programming: Beale's method, restricted basis entry method (Wolfe's method), proof of termination for the definite case, resolution of the semi definite case, duality in quadratic programming; Convex Programming: Methods of feasible directions, Zoutendijk's method, Rozen's gradient projection method for linear constraints, Kelly's cutting plane method to deal with nonlinear constraints.

References:

1. S.S. Rao, Optimization Theory and Applications, Wiley Eastern, 2009.
2. G. Hadley, Nonlinear and Dynamic Programming, Addison Wesley, 2018.
3. M. Bazara and Shetty, Nonlinear Programming: Theory and Algorithms, 3rd edition, John Wiley, 2006.
4. H.S. Kasana, Introductory Operation Research: Theory and Applications, Springer Verlag, 2005.
5. R. L. Rardin, Optimization in Operations research, Pearson Education, 2005.

MAS6203: FUNCTIONAL ANALYSIS [3 1 0 4]

Normed Linear Spaces: Metric on normed linear spaces, completion of a normed space; Banach Spaces: Introduction, subspace of a 120anach space, Holder and Minkowski inequality, completeness of quotient spaces of normed linear spaces, completeness of l_p , L_p , R_n , C_n and $C[a,b]$, incomplete normed spaces, finite dimensional normed linear spaces and subspaces, bounded linear transformation, equivalent formulation of continuity, spaces of bounded linear transformations, continuous linear functional, conjugate spaces, Hahn-Banach extension theorem (real and complex form), Riesz representation theorem for bounded linear functionals on L_p and $C[a,b]$, second conjugate spaces, reflexive space, uniform boundedness principle and its consequences, open mapping theorem and its application, projections, closed graph theorem equivalent norms, weak and strong convergence, their equivalence in finite dimensional spaces, weak sequential compactness, solvability of linear equations in banach spaces; Compact Operator Theory: Compact operator and its relation with continuous operator, compactness of linear transformation on a finite dimensional space, properties of compact operators, compactness of the limit of the sequence of compact operators.

References:

1. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 2003.
2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley, 2007.
3. A. H. Siddiqi, Khalil Ahmad and P. Manchanda, Introduction to Functional Analysis with Applications, Anamaya Publishers, New Delhi, 2006
4. K.C. Rao, Functional Analysis, Narosa Publishing House, 2nd edition, 2006

MAS6204: MEASURE THEORY & INTEGRATION [3 1 0 4]

Measurable Sets: Set functions, intuitive idea of measure, elementary properties of measure, measurable sets and their fundamental properties, Lebesgue measure of a set of real numbers, algebra of measurable sets, Borel set, equivalent formulation of measurable sets in terms of open, closed, non-measurable sets, measurable functions and their equivalent formulations, properties of measurable functions, approximation of a measurable function by a sequence of simple functions, measurable functions as nearly continuous functions, Egoroff theorem, Lusin theorem, convergence in measure and F. Riesz theorem, almost uniform convergence; Measureable Function and Lebesgue Integral: Shortcomings of Riemann integral, Lebesgue integral of a bounded function over a set of finite measure and its properties, Lebesgue integral as a generalization of Riemann integral, bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions, integral of non-negative functions, Fatou lemma, monotone convergence theorem, general Lebesgue integral, Lebesgue convergence theorem, Vitali covering lemma, differentiation of monotonic functions, function of bounded variation and its representation as difference of monotonic functions, differentiation of indefinite integral, Fundamental theorem of calculus, absolutely continuous functions and their properties.

References:

1. W. Rudin, Principles of Mathematical Analysis, 3rd edition, McGraw-Hill, Kogakusha, 2017.
2. H.L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th edition, New York, 1993.
3. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International (P) Limited Published, New Delhi, 2012.
4. G. De Barra, Measure Theory and Integration, Wiley Eastern Ltd., 2003.
5. R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 2012.
6. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.
7. R. R. Goldberg, Methods of Real Analysis, John Wiley & Sons, 2012.

MAS6205: RESEARCH METHODOLOGY & TECHNICAL WRITING [2 1 0 3]

Foundations of Research: Meaning, objectives, motivation, utility, empiricism, deductive and inductive theory, characteristics of scientific method, understanding the language of research; Research Process: Problem identification & formulation, research question, investigation question, measurement issues, hypothesis, qualities of a good hypothesis, types of hypothesis; Research Design: Concept and importance in research, features of a good research design, exploratory research design, descriptive research designs, experimental research design; Types of Data: Classification of data, uses, advantages, disadvantages, sources; Measurement: Concept of measurement, problems in measurement in research, validity and reliability, levels of measurement; Statistical Techniques and Tools: Introduction of statistics, functions, limitations, graphical representation, measures of central tendency, measure of dispersion, skewness, kurtosis, correlation, regression, tests of significance based on t, F, Chi-square, Z and ANOVA test; Paper Writing: Layout of a research paper, Scopus/Web of Science journals, impact factor of journals, when and where to publish, ethical issues related to publishing, plagiarism and self-plagiarism. Introduction to LATEX and MATLAB.

References:

1. C.R. Kothari, Research Methodology Methods & Techniques, New Age International Publishers, Reprint 2008.
2. R. Singh, Research Methodology, Saga Publication, 4th edition, 2014.
3. J. Anderson and M. Poole, Thesis and Assignment Writing, Wiley India 4th edition, 2011.
4. Mukul Gupta and Deepa Gupta, Research Methodology, PHI Learning Private Ltd., New Delhi, 2011.
5. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi, 1999.

MAS6230: LAB ON OPTIMIZATION THEORY AND TECHNIQUES [0 0 2 1]

The following practical will be performed using software: Fibonacci golden section and quadratic interpolation methods for one dimensional problems, Kuhn-Tucker necessary conditions for optimality, solution of simple NLPP using K-T conditions, Beale's method, restricted basis entry method (Wolfe's method), duality in quadratic programming, Methods of feasible directions, Zoutendijk's method, Rozen's gradient projection method for linear constraints, Kelly's cutting plane method to deal with nonlinear constraints.

Reference:

1. M.W. Carter and Camille C, Operation Research: A Practical Introduction, CRC Press, 1st edition, 2000.

MAS6270: SEMINAR

Students are expected to do the following:

1. **Selection of Topic:** Choose a relevant and advanced topic from pure or applied mathematics.
2. **Literature Survey:** Understand the background concepts, definitions, and motivation of the topic.
3. Mathematical Understanding and Analysis
4. **Preparation of Seminar Report:** Write a well-structured seminar report, usually containing Title and Abstract, Introduction and Motivation, Preliminaries/Basic Concepts, Main Results, Illustrative Examples or Applications, Conclusion and Future Scope, References (books, journals, papers)
5. Seminar Presentation

MAS7101: FLUID DYNAMICS [3 1 0 4]

Kinematics of fluid: Lagrangian and Eulerian approaches, Streamlines, Path lines, Streak lines, Velocity potential, Velocity, and circulation, Irrotational and rotational motions. Vortex lines, Equation of Continuity in Lagrangian and Eulerian approaches. Lagrange's equations of motion, Euler's equation of motion, Bernoulli's theorem, Kelvin circulation theorem, Vorticity equation. Energy equation for an incompressible flow, Boundary conditions, Stream functions, Complex potential, Stokes stream functions, Sources, Sinks and doublets, Images in a rigid impermeable infinite plane and in impermeable spherical surfaces, Milne-Thomson Circle theorem. Blasius theorem, Joukowski transformation, Vortex motion and its elementary properties, Velocity in a vortex field, Motion of a circular vortex, Infinite rows of vortices, Kármán vortex street. Conservation laws, Navier-Stokes equations for 2D and 3D, Couette flow, Hagen-Poiseuille flow, steady motion of a viscous fluid between two parallel planes and through cylindrical pipes.

References:

1. G.K. Batchelor, An Introduction to Fluid Mechanics, Cambridge University Press, New Delhi, 2012.
2. J. L. Bansal, Viscous Fluid Dynamics, Oxford & IBH publication, 2004.
3. M. D. Raisinghania, Fluid Dynamics, S. Chand & Comp., Delhi, 2010.
4. H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, 2014.
5. F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers & Distributors, London, 1990

MAS7102: SPECIAL FUNCTIONS [3 1 0 4]

Gauss Hypergeometric Function: Introduction and its properties, Series solution of Gauss hypergeometric equation. Integral representation, Linear and quadratic transformation formulas, Contiguous function relations, Differentiation formulae, Linear relation between the solutions of Gauss hypergeometric equation, Kummer's confluent hypergeometric function and its properties, Integral representation, Kummer's first transformation; Legendre Polynomials: Introduction, Rodrigue's formula, orthogonality, recurrence relations. Functions $P_n(x)$ and $Q_n(x)$ and their properties; Bessel Function: Introduction, $J_n(x)$ and its properties, recurrence relations; Generalized Hypergeometric Function: Definition, Special cases, Series, integral and contour representations, Convergence conditions of these representations, Saalschütz, Whipple theorems, Contiguous function relations, Differentiation and integral formulas, Laguerre polynomial: Introduction, recurrence relations, Properties.

References:

1. G.E. Andrews, R. Askey and R. Rose, Special Functions, Cambridge University Press, 2001.
2. R.Y. Denis and U.P. Singh, Special Function and Their Applications, Dominant Publishers, 2001.
3. N. Saran, S. D. Sharma & T. N. Trivedi, Special Functions: For Mathematical, Physical & Engineering Sciences, Pragati Prakashan, 2008.
4. N. Saran, S.D Sharma, T. N. Trivedi, Special Functions, Pragati Prakashan, 2019

MAS7103: INTEGRAL EQUATIONS & CALCULUS OF VARIATION [3 1 0 4]

Linear Integral Equations: Some basic identities, initial value problems reduced to Volterra integral equations, methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, iterated kernels and Neumann series for Volterra equations, resolvent kernel as a series, Laplace transform method for a difference kernel, solution of a Volterra integral equation of the first kind, boundary value problems reduced to Fredholm integral equations, methods of successive approximation and successive substitution to solve Fredholm equations of second kind, iterated kernels and Neumann series for Fredholm equations, resolvent kernel as a sum of series, Fredholm resolvent kernel as a ratio of two series, Fredholm equations with separable kernels, approximation of a kernel by a separable kernel, Fredholm Alternative, non homogeneous Fredholm equations with degenerate kernels, Green function, use of method of variation of parameters to construct the Green function for a nonhomogeneous linear second order boundary value problem, basic four properties of the Green function, alternate procedure for construction of the Green function by using its basic four properties, reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function, Hilbert-Schmidt theory for symmetric kernels; Calculus of Variation: Motivating problems of calculus of variations, shortest distance, minimum surface of revolution, Brachistochrone problem, isoperimetric problem, Geodesic, fundamental lemma of calculus of variations, Euler equation for one dependent function and its generalization to 'n' dependent functions and to higher order derivatives, conditional extremum under geometric constraints and under integral constraint.

References:

1. A.J. Jerri, Introduction to Integral Equations with Applications, Wiley-Interscience Publication, 1999.
2. R.P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York, 1996.
3. P.C. Bhakta, Integral Transforms, Integral Equations and Calculus of Variations, Sarat, 2011.
4. A.S. Gupta, Calculus of Variations with Applications, PHI Learning, 2015.
5. F.B. Hilderbrand, Methods of Applied Mathematics, Dover Publications, 2005.
6. I.M. Gelfand, S.V. Fomin, Calculus of Variations, Dover Publications, 2000.

MAS7104: THEORY OF FIELD EXTENSIONS [3 1 0 4]

Extension of Fields: Elementary properties, simple extensions, algebraic and transcendental extensions, factorization of polynomials, splitting fields, algebraically closed fields, separable extensions, perfect fields; Galois Theory: Automorphism of fields, monomorphisms and their linear independence, fixed fields, normal extensions, normal closure of an extension, fundamental theorem of Galois theory, Norms and traces, normal basis, Galois fields, cyclotomic extensions, cyclotomic polynomials, cyclotomic extensions of rational number field, cyclic extension, Wedderburn theorem, ruler and compasses construction, solutions by radicals, extension by radicals, generic polynomial, algebraically independent sets, insolvability of the general polynomial of degree $n \geq 5$ by radicals.

References:

1. I.S. Luther and I.B.S. Passi, Algebra, Vol. IV-Field Theory, Narosa Publishing House, 2012.
2. I. Stewart, Galois Theory, Chapman and Hall/CRC, 2004.
3. V. Sahai and V. Bist, Algebra, Narosa Publishing House, 2003.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra, 2nd edition, Cambridge University Press, Indian Edition, 2012.
5. S. Lang, Algebra, 3rd edition, Addison-Wesley, 2002.
6. I. T. Adamson, Introduction to Field Theory, Cambridge University Press, 2007.

MAS7140: MECHANICS OF SOLIDS [2 1 0 3]

Tensor Analysis: Cartesian tensors of different orders, contraction of a tensor, multiplication and quotient laws for tensors, substitution and alternate tensors, symmetric and skew symmetric tensors, isotropic tensors, eigenvalues and eigenvectors of a second order symmetric tensor; Analysis of Stress: Stress vector, normal stress, shear stress, stress components, Cauchy equations of equilibrium, stress tensor of order two, symmetry of stress tensor, stress quadric of Cauchy, principal stresses, stress invariants, maximum normal and shear stresses, mohr diagram; Analysis of Strain: Affine transformations, infinitesimal affine deformation, pure deformation, components of strain tensor and their geometrical meanings, strain quadric of Cauchy, principal strains, strain invariants, general infinitesimal deformation, saint-venant conditions of compatibility, finite deformations; Equations of Elasticity: Generalized Hook's law, Hook's law in an elastic media with one plane of symmetry, orthotropic and transversely isotropic symmetries, homogeneous isotropic elastic media, elastic moduli for an isotropic media, equilibrium and dynamical equations for an isotropic elastic media, Beltrami – Michell compatibility conditions.

References:

1. M. Teodar Atanackovic and Ardesniv Guran, Theory of Elasticity for Scientists and Engineers, Birkhauser, Boston, 2000.
2. A. K. Singh, Mechanics of Solid, Prentice Hall India Learning Private Limited, 2007.
3. A.S. Saada., Elasticity-Theory and applications, Pergamon Press, New York, 2009.
4. D.S. Chandrasekhariah and L. Debnath, Continuum Mechanics, Academic Press, 1994.
5. A.K. Malik and S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991

MAS7141: STOCHASTIC PROCESS [2 1 0 3]

Probability Generating Functions: Introduction, probability generating function, mean, variance, sum of random variables, stochastic sum, generating function of bivariate distribution, Laplace transforms and its properties, Laplace transform of a probability distribution or of a random variable, mean and variance in terms of Laplace transform, three important theorems, randomization and mixtures and classification of distributions; Stochastic Processes: Introduction, definition and examples of stochastic process, classification of general stochastic processes into discrete/continuous time, discrete/continuous state spaces, types of stochastic processes elementary problems, random walk, gambler's ruin problem; Markov Chains: Definition and examples of Markov chain, transition probability matrix, classification of states, recurrence, simple problems, basic limit theorem of Markov chain, stationary probability distribution, applications; Continuous Time Markov Chain: Poisson process and related inter arrival time distribution, pure birth process, pure death process, birth and death process, problems.

References:

1. J. Medhi, Stochastic Processes, New Age International Publication, 2009.
2. S.M. Ross, Stochastic Process, John Wiley, 2008.
3. A. Papoulis and S.U. Pillai, Probability –Random Variables and Stochastic Processes, McGraw Hill Education, 4th edition, 2017.
4. S. Karlin and H.M. Taylor, A First Course in Stochastic Process, Academic Press, 2012.
5. E. Cinlar, Introduction to Stochastic Processes, Dover Books on Mathematics, 2013.
6. H.M. Taylor and S. Karlin, Stochastic Modeling, Academic Press, 1999.

MAS7142: FUZZY SETS & THEIR APPLICATIONS [2 1 0 3]

Fuzzy Sets: Introduction, classical sets vs fuzzy sets, need for fuzzy sets, definition and mathematical representations, level sets, fuzzy functions, Zadeh's extension principle; Operations on Fuzzy Sets: Operations on $[0, 1]$, fuzzy negation, triangular norms, t-conorms, fuzzy implications, aggregation operations, fuzzy functional equations, fuzzy number; Fuzzy Relations: Fuzzy binary and n-ary relations, composition of fuzzy relations, fuzzy equivalence relations, fuzzy compatibility relations, fuzzy relational equations; Possibility Theory: Fuzzy measures, evidence theory, necessity and belief measures, probability measures vs possibility measures; Approximate Reasoning: Fuzzy decision making, fuzzy relational inference, positional rule of inference, efficiency of inference, hierarchical; Fuzzy Controllers: fuzzy if-then rule base, inference engine, Takagi-Sugeno fuzzy systems, function approximation.

References:

1. A.K. Bhargava, Fuzzy Set Theory Fuzzy Logic and Their Applications, S. Chand & Co., 2013.
2. K. Pundir and R. Pundir, Fuzzy Sets and Their Applications, Pragati Prakashan, Meerut, 2008.
3. G. J. Klir and B. Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 2001.
4. H. J. Zimmermann, Fuzzy Set Theory and its Applications, Springer, 2001.

MAS7143: TOPOLOGY- II [2 1 0 3]

Separation Axioms: Regular, normal, T3 and T4 separation axioms, their characterization and basic properties, Urysohn lemma and Tietze extension theorem, regularity and normality of a compact Hausdorff space, complete regularity, complete normality, T5 spaces, their characterization and basic properties, product topological spaces, projection mappings, Tychonoff product topology in terms of standard sub bases and its characterization, separation axioms and product spaces, connectedness, locally connectedness and compactness of product spaces, product space as first axiom space,

Tychonoff product theorem; Embedding and Metrization : Embedding lemma and Tychonoff embedding theorem, metrizable spaces, Urysohn metrization theorem; Nets : Nets in topological spaces, convergence of nets, Hausdorffness and nets, subnet and cluster points, compactness and nets; Filters : Definition and examples, collection of all filters on a set as a poset, methods of generating filters and finer filters, ultra filter and its characterizations, ultra filter principle, image of filter under a function, limit point and limit of a filter, continuity in terms of convergence of filters, Hausdorffness and filters, canonical way of converting nets to filters and vice versa, Stone-Cech compactification, covering of a space, local finiteness, paracompact spaces, paracompactness as regular space, Michael's theorem on characterization of paracompactness, paracompactness as normal space, A. H. Stone theorem, Nagata-Smirnov metrization theorem.

References:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 2017.
2. K.D. Joshi, Introduction to General Topology, New Age International Private Limited, 2017
3. J. L. Kelly, General Topology, Springer Verlag, New York, 2000.
4. J. R. Munkres, Topology, Pearson Education Asia, 2002.
5. W.J. Pervin, Foundations of General Topology, Academic Press Inc. New York, 2014.
6. K. Chandrasekhara Rao, Topology, Narosa Publishing House Delhi, 2009.

MAS7144: LINEAR MODELS [2 1 0 3]

Simple Regression Models: Straight line relationship between two variables, Gauss Markoff theorem, precision of the estimated regression, examination of the regression equation, lack of fit and pure error, fitting a straight line in matrix form, variance and covariance of b_0 and b_1 from the matrix calculation, variance of Y using the matrix development, orthogonal columns in the X -matrix, partial F-Test and sequential F-tests, selection of best regression equations by step wise procedure, bias in regression estimates, residuals, polynomial models and orthogonal polynomials; Multiple Regression Estimation: Introduction, the model, estimation of β and σ^2 , geometry of least-squares, the model in centered form, normal model, R^2 in fixed x -regression, generalized least-square, model misspecification, tests of hypothesis and confidence intervals, model validation and diagnostics.

References:

1. R.B. Bapat, Linear Algebra and Linear Models, 2nd edition Hindustan Book Agency, 1999.
2. R. Rao, Linear Models, Least Squares and Alternatives, 2nd edition, Springer, 1999.
3. D.C. Montgomery, E.A. Peck and G. G. Vining, Introduction to Linear Regression Analysis, 4th edition, John Wiley & Sons, 2006.
4. A. C. Rencher and G.B. Schaalje, Linear Models in Statistics, 2nd Edition, John Wiley & Sons, 2008.
5. S.R. Searle, Linear Models, Wiley Classic Library, Wiley-Interscience, 1997.

MAS7145: COMPUTATIONAL FLUID DYNAMICS [2 1 0 3]

Introduction: Basic equations of Fluid dynamics, analytic aspects of partial differential equations classification, boundary conditions, maximum principles, boundary layer theory, finite difference and finite volume discretizations, vertex-centred discretization, cellcentred discretization, upwind discretization; Grid Analysis: Non uniform grids in one dimension, finite volume discretization of the stationary convection-diffusion equation in one dimension, schemes of positive types, defect correction, non-stationary convection diffusion equation; Stability of the system: Stability definitions, discrete maximum principle, incompressible Navier-Stokes equations, boundary conditions, spatial discretization on collocated and on staggered grids, temporal discretization on staggered grid and on collocated grid; Analytical Solutions: Iterative methods, stationary methods, Krylov subspace methods,

multigrade methods, fast Poisson solvers, iterative methods for incompressible Navier-Stokes equations, Shallow-water equations – one and two dimensional cases, Godunov order barrier theorem, linear schemes, scalar conservation laws, Euler equation in one space dimension – analytic aspects, approximate Riemann solver of Roe, Osher scheme, flux splitting scheme, numerical stability, Jameson – Schmidt – Turkel scheme, higher order schemes.

References:

1. P. Wesseling, Principles of Computational Fluid Dynamics, Springer Verlag, 2000.
2. J.F. Wendt, J.D. Anderson, G. Degrez and E. Dick, Computational Fluid Dynamics: An Introduction, Springer Verlag, 1996.
3. K. Muralidher, Computational Fluid Flow and Heat Transfer, Narosa Pub. House, 2013.
4. T.J. Chung, Computational Fluid Dynamics, Cambridge Uni. Press, 2014.

MAS7146: MATHEMATICAL STATISTICS [2 1 0 3]

Probability: Basic concepts of probability, conditional probability, Bayes theorem and its applications; Random Variable and Probability Functions: discrete and continuous random variables, probability mass and density functions, distribution function, concepts of bivariate random variable: joint, marginal and conditional distributions, cumulative generating function; Mathematical Expectation and its properties, variance, covariance, moment generating function; Probability Distributions: Discrete Distributions- Uniform, Bernoulli, Binomial, Poisson and Geometric distributions with their properties; Continuous Distributions- Uniform, Normal, Exponential, Beta and Gamma distributions with their properties; Testing of Hypothesis: Parameter and statistic, sampling distribution and standard error of estimate, null and alternative hypotheses, simple and composite hypotheses, critical region, Level of significance, one tailed and two tailed tests, two types of errors; Tests of Significance: Large sample tests for single mean, single proportion, difference between two means and two proportions.

References:

1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Co., 3rd edition, New Delhi, 2008.
2. V.K. Rohtagi and A.K.M. E Saleh, An Introduction to Probability & Statistics, John Wiley & Sons, 2011.
3. P. L. Meyer, Introductory Probability and Statistical Applications, Addison-Wesley, 2017.
4. W. Feller, An Introduction to Probability Theory and Its Applications, Vol. 1, 3rd edition, John Wiley, 2005.
5. P. Mukhopadhyay, Mathematical Statistics, Books & Allied (P) Ltd., 2009.
6. G. Casella, and R.L. Berger, Statistical Inference, 2nd edition. Thomson Duxbury, 2002.
7. R.V. Hogg, and E.A. Tanis, Probability and Statistical Inference, 9th edition, Macmillan Publishing Co. Inc., 2014