Scheme of Examination
M.Sc. (Mathematics)
Under Choice Based Credit System (CBCS)
Department of Mathematics, CDLU, Sirsa

M. Sc. (Final) Mathematics (with effect from session 2018-19)

Paper Code No.	Title of the paper/ Subject	Hrs per week L+P	Marks (Theory)	Marks (Internal Assessment)	Marks (Practical)	Total Marks	Credit
Semester-III							
(Core Courses)							
MTHCC-2301	Topology	4+0	70	30	00	100	4
MTHCC-2302	Fluid Mechanics	4+0	70	30	00	100	4
(Core Elective Courses) (Any three of the following)							
MTHCE-2303	Integral Equations	4+0	70	30	00	100	4
MTHCE-2304	Mathematical Statistics	4+0	70	30	00	100	4
MTHCE-2305	Advanced Complex Analysis	4+0	70	30	00	100	4
MTHCE-2306	Advanced Mechanics of Solids	4+0	70	30	00	100	4
MTHCE-2307	Advanced Discrete Mathematics	4+0	70	30	00	100	4
MTHCE-2308	Fuzzy Sets and Fuzzy Logic	4+0	70	30	00	100	4
MTHCE-2309	Information Theory	4+0	70	30	00	100	4
MTHCE-2310	Difference Equations	4+0	70	30	00	100	4
MTHCE-2311	Financial Mathematics	4+0	70	30	00	100	4
MTHCE-2312	Number Theory	4+0	70	30	00	100	4
MTHCE-2313	Wavelet Analysis	4+0	70	30	00	100	4

Paper Code No.	Title of the paper/ Subject	Hrs per week L+P	Marks (Theory)	Marks (Internal Assessment)	Marks (Practical)	Total Marks	Credit
			Semester-IV				
			(Core Courses)				
MTHCC-2401	Functional Analysis	4+0	70	30	00	100	4
MTHCC-2402	Partial Differential Equations	4+0	70	30	00	100	4
MTHCC-2403	Computer Programming in MATLAB	0+4	00	00	100	100	4
			(Core Elective Courses) (Any three of the following)				
MTHCE-2404	Mathematical Aspect of Seismology	4+0	70	30	00	100	4
MTHCE-2405	Operation Research	4+0	70	30	00	100	4
MTHCE-2406	Advanced Fluid Mechanics	4+0	70	30	00	100	4
MTHCE-2407	Boundary Value Problems	4+0	70	30	00	100	4
MTHCE-2408	Algebraic Topology	4+0	70	30	00	100	4
MTHCE-2409	Analytic Number Theory	4+0	70	30	00	100	4
MTHCE-2410	Algebraic Coding Theory	4+0	70	30	00	100	4
MTHCE-2411	Control Theory	4+0	70	30	00	100	4
MTHCE-2412	Bio-Mechanics	4+0	70	30	00	100	4
MTHCE-2413	Algebraic Number Theory	4+0	70	30	00	100	4

MTHCC–2301: Topology

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Definition and examples of topological spaces, Neighborhoods, closed sets, closure, Interior, exterior and boundary of a set, Adherent points and Accumulation points, closure of a set as a set of adherent points, derived sets, properties of closure operator, dense subsets.
Base and sub-base for a topology, Neighbourhood system of a point and its properties, Base for a neighbourhood system, Subspaces and relative topology. First countable, second countable and separable spaces, their relationships and hereditary properties, about countability of a collection of disjoint open sets in a separable and second countable space, Lindelof's theorems.

Unit: 2.

Comparison of topologies on a set, about intersection, union, infimum and supremum of a collection of topologies on a set. Definition, examples and characterizations of continuous functions, composition of continuous functions, open and closed functions, homeomorphism. Tychonoff product topology, defining base and sub-base for product topology, projection maps, characterization of product topology as smallest topology with continuous projections, continuity of a function from a space into a product of spaces, countability and product spaces.

Unit: 3.

Separation axioms, T_0, T_1, T_2, Regular, T_3 spaces, their characterization and hereditary properties, productive properties of T_1 and T_2 spaces, completely regular and Tychonoff spaces, their hereditary and productive properties. Normal and T_4 spaces, normality of a regular Lindelof space, Urysohn's lemma, complete regularity of a regular normal space, T_4 implies Tychonoff, Tietze's extension theorem.

Unit: 4.

Connected spaces, separation of a topological space, definition of connectedness in terms of separation, characterization of connectedness, connected subsets and their properties, continuity and connectedness, connectedness and product spaces.
Compactness: definition and examples of compact spaces and subsets, compactness in terms of finite intersection property, continuity and compact sets, compactness and separation

properties, closedness of compact subset and a continuous map from a compact space into a Hausdorff and its consequence, regularity and normality of a compact Hausdorff space.

Books Recommended:

1. J. L. Kelly: General Topology, Springer.
2. J. R. Munkers: Topology, Prentice Hall.
3. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw Hill.

MTHCC–2302: Fluid Mechanics

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Kinematics of fluid in motion: Real fluids and ideal fluids, Velocity at a point of a fluid. Lagrangian and Eulerian methods and the relation between them. Stream lines, path lines and streak liens, vorticity and circulation, Vortex lines. Acceleration and Material derivative.
Equation of continuity in vector form, Cartesian, cylindrical and spherical coordinates. Reynolds transport Theorem. Working rules for writing equation of continuity in some specific flows. General analysis of fluid motion. Properties of fluids- static and dynamic pressure. Boundary surfaces and boundary surface conditions. Inotational and rotational motions. Velocity potential.

Unit: 2.

Equation of Motion : Lagrange's and Euler's equations of Motion. Conservative field of force. Bernoulli's theorem. Applications of the Bernoulli Equation in one dimensional flow problems. Kelvins circulation theorem, vorticity equation.
Energy equation for incompressible flow. Kinetic energy of irrotational flow. Kelvins minimum energy theorem. Mean potential over a spherical surface. Kinetic energy of infinite liquid. Uniqueness theorems. Elementary fluid motion in two dimensions: stream function, irrotational motion, complex potential, sources, sinks and doublets.

Unit: 3.

Real or Viscous fluids: Newton's Law of viscosity, Newtonian and non-Newtonian fluids. State of stress at a point. Nature of stresses, transformation of stress components. Nature of rate of strain, transformation of the rate of strain. Principal stress & strain rate. Relation between stress and rate of strain.
Navier Stoke's equations of motion of a viscous fluid in vector from and in term of Cartesian, cylindrical and spherical coordinators. The energy equation. Diffusion of vorticity. vorticity equation: Energy dissipation due to viscosity.

Unit: 4.

Laminar's flow: Steady flow between two parallel planes: plane Poiseuille flow, plane Couette flow, generalized plane Couette flow.
Steady flow in pipes: flow through a circular pipe (Hagen-Poiseuille flow), laminar steady flow between two coaxial circular cylinders, Laminar steady flow between concentric rotating cylinders. Uniqueness Theorem. Steady viscous flow in tubes of uniform elliptic, equilateral triangular and rectangular cross sections.

Books Recommended:

1. F. Chorlton, Text-book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985.
2. Michael E.O. Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, John Wiley & Sons, 1986.
3. S. W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Ltd., New Delhi, 1976.
4. G.K. Batchelor, An Introduciton to Fluid Mechanics, Foundation Books, New Delhi, 1994.
5. A.J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics Springer-Verlag, New York, 1993.
6. L.D. Landau and E.M. Lipschitz, Fluid Mechanics Pergamon Press, London, 1985.
7. H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York, 1979.
8. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
9. A.D. Young, Boundary Layers, AIAA Education Series, Washington DC, 1989.
10. W.H. Besant and A.S. Ramsey, A Treatise on Hydromechanics, Part-II, CBS Publishers, Delhi, 1988.

MTHCE–2303: Integral Equations

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Definition of Integral Equations and their classifications. Eigen values and Eigen functions. Special kinds of Kernel Convolution Integral. The inner or scalar product of two functions. Reduction to a system of algebraic equations. Fredholm alternative, Fredholm theorem, Fredholm alternative theorem, An approximate method.

Unit: 2.

Method of successive approximations, Iterative scheme for Fredholm and Volterrra Integral equations of the second kind. Conditions of uniform convergence and uniqueness of series solution. Some results about the resolvent Kernel. Application of iterative scheme to Volterra integral equations of the second kind.
Classical Fredholm's theory, the method of solution of Fredholm equation. Fredholm's First theorem, Fredholm's second theorem, Fredhom's third theorem.

Unit: 3.

Symmetric Kernels, Introduction, Complex Hilbert space. An orthonormal system of functions, Riesz-Fisher theorem, A complete two-Dimensional orthonormal set over the rectangle $a \le s \le b, c \le t \le d$. Fundamental properties of Eigenvalues and Eigenfunctions for symmetric Kernels. Expansion in eigen functions and Bilinear form. Hilbert-Schmidt theorem and some immediate consequences.

Unit: 4.

Definite Kernels and Mercer's theorem. Solution of a symmetric Integral Equation. Approximation of a general L_2-Kernel (Not necessarily symmetric) by a separable Kernel. The operator method in the theory of integral equations. Rayleigh-Ritz method for finding the first eigenvalue.
The Abel Intergral Equation. Inversion formula for singular integral equation with Kernel of the type h(s)-h(t), $0 < \alpha < 1$, Cauchy's principal value for integrals solution of the Cauchy-type singular integral equation, closed contour, unclosed contours and the Riemann-Hilbert problem. The Hilbert-Kernel, solution of the Hilbert-Type singular Intergal equation.

Books Recommended:

1. R.P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
2. S.G. Mikhlin, Linear Integral Equations (translated from Russian) Hindustan Book Agency, 1960.
3. I.N. Sneddon, Mixed Boundary Value Problems in potential theory, North Holland, 1966.
4. I. Stakgold, Boundary Value Problems of Mathematical Physics Vol. I, II, Mac. Millan, 1969.
5. M.D. Raishinghania, Integral Equations and Boundary value problems, S. Chand and Company Pvt. Ltd. 2007.

MTHCE-2304: Mathematical Statistics

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Random distribution: preliminaries, Probability density function, Probability models, Mathematical Expectation, Chebyshev's Inequality; Conditional probability, Marginal and conditional distributions, Correlation coefficient, Stochastic independence.
Frequency distributions: Binomial, Poissson, Gamma, Chi-square, Normal, Bivariate normal distributions.

Unit: 2.

Distributions of functions: Sampling, Transformations of variables: discrete and continuous; t & F distributions; Change of variable technique; Distribution of order; Moment-generating function technique; other distributions and expectations.

Unit: 3.

Limiting distributions: Stochastic convergence, Moment generating function, Related theorems.
Intervals: Random intervals, Confidence intervals for mean, differences of means and variance; Bayesian estimation.

Unit: 4.

Estimation & sufficiency: Point estimation, sufficient statistics, Rao-Blackwell Theorem, Completeness, Uniqueness, Exponential PDF, Functions of parameters; Stochastic independence.

Books Recommended:

1. Baisnab and M. Das: Elements of Probability and Statistics, Tata McGraw Hill.
2. J. E. Freund: Mathematical Statistics, Prentice Hall of India.
3. R. V. Hogg and A. T. Criag: Introduction to Mathematical Statistics, Maxwell McMillan.
4. S. C. Gupta and V. K. Kapoor: Fundamentals of Mathematical Statistics.

MTHCE–2305: Advanced Complex Analysis

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Convex functions and Hadamard's three circles theorem, The Phragmen-Lindelof Theorem The space of continuous functions $C(G,\Omega)$, Arzela-Ascoli theorem, Spaces of analytic functions, Hurwitz's theorem, Montel's theorem.

Unit: 2.

Spaces of meromorphic functions, Riemann mapping theorem, infinite products, Weierstrass factorization theorem, Factorization of sine function, Gamma function and its properties, functional equation for gamma function, Bohr-Mollerup theorem, Reimann-zeta function, Riemann's functional equation, Euler's theorem.

Unit: 3.

Runge's theorem, Mittag-Leffler's theorem, Analytic continuation, uniqueness of direct analytic continuation, uniqueness of analytic continuation along a curve, Power series method of analytic continuation, Schwarz reflection principle, Monodromy theorem and its consequences.
Basic properties of harmonic functions, Harmonic function as a disk, Poisson's Kernel. Dirichlet problem for a unit disk, Harnack's inequality, Harnack's theorem, Dirichlet problem for a region, Green's function.

Unit: 4.

Entire functions :Jensen's formula, Poisson Jensen formula.The genus and order of an entire function, Hadamard's factorization theorem.
The range of an analytic function: Bloch's theorem, Little-Picard theorem, Schottky's theorem, Montel-Carathedory theorem, Great Picard theorem

Books Recommended:

1. Conway, J.B., Functions of One complex variables Narosa Publishing, 2000.
2. Ahlfors, L.V., Complex Analysis, McGraw-Hill Book Company, 1979.
3. Churchill, R.V. and Brown, J.W., Complex Variables and Applications McGraw Hill Publishing Company, 1990.
4. Priestly, H.A., Introduction to Complex Analysis Claredon Press, Orford, 1990.
5. Liang-shin Hahn & Bernard Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
6. D.Sarason, Complex Function Theory, Hindustan Book Agency, Delhi, 1994.

7. Mark J.Ablewitz and A.S.Fokas, Complex Variables : Introduction & Applications, Cambridge University Press, South Asian Edition, 1998.
8. E.C.Titchmarsn, The Theory of Functions, Oxford University Press, London.
9. S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.

MTHCE-2306: Advanced Mechanics of Solids

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Extension : Extension of beams, bending of beams by own weight and terminal couples.
Torsion : Torsion of cylindrical bars; Torsional rigidity. Torsion and stress functions. Lines of shearing stress. Simple problems related to equilateral triangle, grooves; Torsion of rectangular beam, Torsion of triangular prism.

Unit: 2.

Torsion problems through conformal mapping; Torsion-membrane analogy; Torsion of hollow beams. Torsion of anisotropic beams; Flexure/bending of circular/ elliptic/ rectangular beams; Deformation/torsion of cylinders by lateral loads.

Unit: 3.

Two dimensional problems: Plane stress. Generalized plane stress. Airy stress function. General solution of biharmonic equation, Stresses and displacements in terms of complex potentials. The structure of functions of $\varphi(z)$ and $\psi(z)$. First and second boundary-value problems in plane elasticity. Existence and uniqueness of the solutions. Basic problem for circular finite/infinite region.

Unit: 4.

Three dimensional problems: general solutions: concentrated forces: deformation by normal loads: The problem of Boussinesq: Elastic sphere: pressures, harmonics, equilibrium: Integration method: Thermoelastic problems: Vibrations in elastic solids.

Books Recommended:

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1977.
2. A.E.H. Love, A Treatise on the Mathematical Theory of Elasticity Dover Publications, New York.
3. Y.C. Fung, Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
4. D.S. Chandrasekharaiah and L. Debnath, Continuum Mechanics, Academic Press, 1994.
5. S. Timoshenko and N. Goodier, Theory of Elasticity, McGraw Hill, New York, 1970.
6. I.H. Shames, Introduction to Solid Mechanics, Prentice Hall, New Delhi, 1975.

MTHCE–2307: Advanced Discrete Mathematics

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Partially ordered sets and lattices. Lattice as an algebraic system. Sublattices. Isomorphism of lattices. Distributive and modular lattices. Lattices as intervals. Similar and projective intervals. Chains in lattices. Zassenhaus's Lemma and Schreier Theorem. Composition chain and Jordan Holder Theorem. Chain conditions. Fundamental dimensionality relation for modular lattices. Decomposition theory for lattices with ascending chain conditions, i.e. reducible and irreducible elements. Independent elements in lattices.

Unit: 2.

Points (atoms) of a lattice. Complemented lattices. Chain conditions and complemented lattices. Boolean algebras. Conversion of a Boolean algebra into a Boolean ring with unity and vice-versa. Direct product of Boolean algebras. Uniqueness of finite Boolean algebras. Boolean functions and Boolean expressions. Application of Boolean algebra to switching circuit theory.

Unit: 3.

Graphs. Konisberg seven bridges problem. Finite and infinite graphs. Incidence vertex. Degree of a vertex. Isolated and pendant vertices. Null graphs. Isomosphism of graphs. Subgraphs, walks, paths and circuits. Connected and disconnected graphs. Components of a graph. Euler graphs. Hamiltonian paths and circuits. The traveling salesman problem. Trees and their properties. Pendant vertices in a tree. Rooted and binary tree. Spanning tree and fundamental circuits. Spanning tree in a weighted graph.

Unit: 4.

Cutsets and their properties. Fundamental circuits and cutsets. Connectivity and separability. Network flows. Planner graphs. Kuratowski's two graphs. Representation of planner graphs. Euler formula for planner graphs. Vector space associated with a graph. Basis vectors of a graph. Circuit and cutset subspaces. Intersection and joins of W_Γ and W_S. Incidence matrix A(G) of a graph G. Submatrices of A(G). Circuit matrix. Fundamental circuit matrix and its rank. Cutset matrix, path matrix and adjacency matrix of a graph.

Books Recommended:

1. Narsingh Deo, Graph Theory with application to Engineering and Computer Science, Prentice Hall of India.
2. Nathan Jacobson, Lectures in Abstract Algebra Vol.I, D.Van Nostrand Company, Inc.

3. L.R. Vermani, A course in discrete Mathematical structures(Imperial College Shalini Press London 2011).
4. J. P. Tremblay & R. Manohar; Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Book Co., 1997.
5. Seymour Lepschutz; Finite Mathematics (International edition 1983), McGraw-Hill Book Company, New York.
6. C. L. Liu: Elements of Discrete Mathematics, McGraw-Hili Book Co.

MTHCE–2308: Fuzzy Sets and Fuzzy Logic

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Fuzzy Sets: Basic definitions, α-cuts, strong α-cuts, level set of a fuzzy set, support of a fuzzy set, the core and height of a fuzzy set, normal and subnormal fuzzy sets, convex fuzzy sets, cutworthy property, strong cutworthy property, standard fuzzy set operations, standard complement, equilibrium points, standard intersection, standard union, fuzzy set inclusion, scalar cardinality of a fuzzy set, the degree of subsethood
Additional properties of α-cuts involving the standard fuzzy set operators and the standard fuzzy set inclusion, Representation of fuzzy sets, three basic decomposition theorems of fuzzy sets Extension principle for fuzzy sets: the Zedah's extension principle, Images and inverse images of fuzzy sets, proof of the fact that the extension principle is strong cutworthy but not cutworthy.

Unit: 2.

Operations on fuzzy sets: types of operations, fuzzy complements, equilibrium of a fuzzy complement, equilibrium of a continuous fuzzy complement, first and second characterization theorems of fuzzy complements
Fuzzy intersections (t-norms), standard fuzzy intersection as the only idempotent t-norm, standard intersection, algebraic product, bounded difference and drastic intersection as examples of t-norms, decreasing generator, the Pseudo-inverse of a decreasing generator, increasing generators and their Pseudo-inverses, convertion of decreasing generators and increasing generators to each other, characterization theorem of t-norms(statement only). Fuzzy unions (t-conorms), standard union, algebraic sum, bounded sum and drastic union as examples of t-conorms, characterization theorem of t-conorms (Statement only), combination of operations, aggregation operations.

Unit: 3.

Fuzzy numbers, relation between fuzzy number and a convex fuzzy set, characterization of fuzzy numbers in terms of its membership functions as piecewise defined functions, fuzzy cardinality of a fuzzy set using fuzzy numbers, arithmetic operations on fuzzy numbers, extension of standard arithmetic operations on real numbers to fuzzy numbers, lattice of fuzzy numbers, (R, MIN, MAX) as a distributive lattice, fuzzy equations, equation $A+X = B$, equation $A.X = B$
Fuzzy Relations: Crisp and fuzzy relations, projections and cylindrical extensions, binary fuzzy relations, domain, range and height of a fuzzy relation, membership matrices, sagittal diagram, inverse of a fuzzy relation, composition of fuzzy relations, standard composition, max min composition, relational join, binary relations on a single set, directed graphs, reflexive irreflexive, antireflexive, symmetric, asymmetric, antisymmetric, transitive (max-

min transitive), non transitive, antitransitive fuzzy relations. Fuzzy equivalence relations, fuzzy compatibility relations, α-compatibility class, maximal α-compatibles, complete α-cover, reflexive undirected graphs, fuzzy ordering relations, fuzzy upper bound, fuzzy pre ordering, fuzzy weak ordering, fuzzy strict ordering, fuzzy morphisms. Sup-i compositions of Fuzzy relations, Inf-i compositions of Fuzzy relations.

Unit: 4.

Possibility Theory : Fuzzy measures, continuity from below and above, semicontinuous fuzzy measures, examples and simple properties; Evidence Theory, belief measure, superadditivity, monotonicity, plausibility measure, subadditivity, basic assignment, its relation with belief measure and plausibility measure, focal element of basic assignment, body of evidence, total ignorance, Dempster's rule of combination, examples; Possibility Theory, necessity measure, possibility measure, implications, possibility distribution function, lattice of possibility distributions, joint possibility distribution. Fuzzy sets and possibility theory, Possibility theory versus probability theory

Fuzzy Logic: An overview of classical logic, about logic functions of two variables. Multivalued logics, Fuzzy propositions,Fuzzy Quantifiers,Linguistic Hedges, Inference from conditional fuzzy propositions, inference from conditional and qualified propositions, inference from unqualified propositions.

Books Recommended:

1. G. J. Klir and B. Yuan : Fuzzy Sets and Fuzzy : Logic Theory and Applications, Prentice Hall of India, 2008.
2. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
3. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
4. John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1999.
5. A.K. Bhargava, Fuzzy Set Theory, Fuzzy Logic & their Applications, S. Chand & Company Pvt. Ltd., 2013.

MTHCE–2309: Information Theory

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Measure of Information – Axioms for a measure of uncertainty, The Shannon entropy and its properties, Joint and conditional entropies, Transformation and its properties.
Noiseless coding – Ingredients of noiseless coding problem, Uniquely decipherable codes, Necessary and sufficient condition for the existence of instantaneous codes, Construction of optimal codes.

Unit: 2.

Discrete memoryless Channel - Classification of channels, Information processed by a channel, Calculation of channel capacity, Decoding schemes, The ideal observer, The fundamental theorem of Information Theory and its strong and weak converses.

Unit: 3.

Continuous Channels – The time-discrete Gaussian channel, Uncertainty of an absolutely continuous random variable, The converse to the coding theorem for time-discrete Gaussian channel, The time-continuous Gaussian channel, Band-limited channels.

Unit: 4.

Some intuitive properties of a measure of entropy – Symmetry, normalization, expansibility, boundedness, recursivity, maximality, stability, additivity, subadditivity, nonnegativity, continuity, branching etc.

Books Recommended:

1. R. Ash: Information Theory, Interscience Publishers, New York, 1965.
2. F. M. Reza: An introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
3. J. Aczel and Z. daroczy: On measures of information and their characterization, Academic press, new York.

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MTHCE–2310: Difference Equations

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Introduction, Difference Calculus- The Difference Operator, Summation, Generating functions and approximate summation.

Unit: 2.

Linear Difference Equations - First order equations, General results for linear equations, Equations with constant coefficients, Applications, Equations with variable coefficients, Nonlinear equations that can be linearized, The z- Transform

Unit: 3.

Stability Theory - Initial value problems for linear systems, Stability of linear systems, Stability of nonlinear systems, Chaotic behaviour.

Unit: 4.

Asymptotic methods Introduction, Asymptotic analysis of sums, Linear equations, Nonlinear equations.
The self-adjoint second order linear equation, Introduction, Sturmian Theory, Green's functions, Disconjugacy, The Riccati Equations, Oscillation.

Books Recommended:

1. Walter G. Kelley and C. Allan: Peterson-Difference Equations, An Introduction with Applications, Academic Press Inc., Harcourt Brace Joranovich Publishers, 1991.
2. Calvin Ahlbrandt and C. Allan: Peterson, Discrete Hamiltonian Systems, Difference Equations, Continued Fractions and Riccati Equations, Kluwer, Boston.

MTHCE–2311: Financial Mathematics

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.
Fundamentals of Financial Mathematics.
Asset Price Model.

Unit: 2.
Black-Scholes Analysis
Variations on Black-Scholes models.

Unit: 3.
Numerical Methods
American Option
Exotic Options.

Unit: 4.
Path-Dependent Options
Bonds and Interest Rate Derivatives
Stochastic calculus.

Books Recommended:

1. Financial Mathematics: I-Liang Chern Department of Mathematics, National Taiwan University
2. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge Univ. Press.
3. Robert J. Elliott and P. Ekkehard Kopp, Mathematics of Financial Markets, Springer-Verlag, New York Inc.
4. Robert C. Marton, Continuous-Time Finance, Basil Blackwell Inc.
5. Daykin C.D., Pentikainen T. and Pesonen M., Practical Risk Theory for Actuaries, Chapman & Hall.

MTHCE–2312: Number Theory

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.
The equation ax+by = c, simultaneous linear equations, Pythagorean triangles, assorted examples, ternary quadratic forms, rational points on curves.

Unit: 2.
Farey sequences, rational approximations, Hurwitz theorem, irrational numbers, Geometry of Numbers, Blichfeldt's principle, Minkowski's Convex body theorem Lagrange's four square theorem.

Unit: 3.
Euclidean algorithm, infinite continued fractions, irrational numbers, approximations to irrational numbers, Best possible approximations, Periodic continued fractions, Pell's equation.

Unit: 4.
Partitions, Ferrers Graphs, Formal power series, generating functions and Euler's identity, Euler's formula, bounds on P(n), Jacobi's formula, a divisibility property.

Books Recommended:

1. An Introduction to the Theory of Numbers: Ivan Niven, Herbert S. Zuckerman, Hugh L Montgomery, John Wiley & Sons(Asia)Pvt. Ltd. (Fifth Edition)

MTHCE–2313: Wavelet Analysis

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Fourier Transform: The finite Fourier transform, the circle group T, convolution to T, (L^1(T),+,*) as a Banach algebra, convolutions to products, convolution on T, the exponential form of Lebesgue's theorem, Fourier transform : trigonometric approach, exponential form, Basics/examples.
Fourier transform and residues, residue theorem for the upper and lower half planes, the Abel kernel, the Fourier map, convolution on R, inversion, exponential form, inversion, trigonometric form, criterion for convergence, continuous analogue of Dini's theorem, continuous analogue of Lipschitz's test, analogue of Jordan's theorem.

Unit: 2.
(C,1) summability for integrals, the Fejer-Lebesgue inversion theorem,the continuous Fejer Kernel, the Fourier map is not onto, a dominated inversion theorem, criterion for integrability of $\hat{f}$, Approximate identity for L(1), Fourier Sine and Cosine transforms, Parseval's identities, the L_2 theory, Parseval's identities for L_2, inversion theorem for L_2 functions, the Plancherel theorem, A sampling theorem, the Mellin transform, variations.

Unit: 3.
Discrete Fourier transform, the DFT in matrix form, inversion theorem for the DFT, DFT map as a linear bijection, Parseval's identities,cyclic convolution, Fast Fourier transform for $N=2^k$, Buneman's Algorithm, FFT for N=RC, FFT factor form.

Unit: 4.
Wavelets : orthonormal basis from one function , Multiresolution Analysis, Mother wavelets yield Wavelet bases, Haar wavelets, from MRA to Mother wavelet, Mother wavelet theorem, construction of scaling function with compact support, Shannon wavelets, Riesz basis and MRAs, Franklin wavelets, frames, splines, the continuous wavelet transform.

Books Recommended:

1. G. Bachman, L. Narici and E. Beckenstein : Fourier and Wavelet Analysis, Springer, 2000.
2. Hernandez and G. Weiss : A first course on wavelets, CRC Press, New York, 1996
3. C. K. Chui: An introduction to Wavelets, Academic Press, 1992
4. I. Daubechies : Ten lectures on wavelets, CBMS NFS Regional Conferences in Applied Mathematics, 61, SIAM, 1992

5. V. Meyer, Wavelets, algorithms and applications SIAM, 1993
6. M.V. Wickerhauser: Adapted wavelet analysis from theory to software, Wellesley,MA, A.K. Peters, 1994
7. D. F. Walnut: An Introduction to Wavelet Analysis, Birkhauser, 2002
8. K. Ahmad and F.A. Shah: Introduction to Wavelets with Applications, World Education Publish.

MTHCC-2401: Functional Analysis

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Normed linear spaces, Banach spaces, finite dimensional normed spaces and subspaces, equivalent norms, compactness and finite dimension, F.Riesz's lemma, Bounded and continuous linear operators, differentiation operator, integral operator, bounded linear extension, linear functionals, bounded linear functionals, continuity and boundedness, normed spaces of operators, dual spaces with examples.

Unit: 2.

Hahn-Banach theorem for normed linear spaces, application to bounded linear functionals on C[a,b], Riesz-representation theorem for bounded linear functionals on C[a,b], adjoint operator, norm of the adjoint operator.Reflexive spaces, uniform boundedness theorem and some of its applications to the space of polynomials and fourier series.

Unit: 3.

Strong and weak convergence, Open mapping theorem, bounded inverse theorem, closed linear operators, closed graph theorem, differential operator, relation between closedness and boundedness of a linear operator.
Inner product spaces, Hilbert spaces and their examples, pythagorean theorem, Apolloniu's identity, Schwarz inequality, continuity of innerproduct, completion of an inner product space, subspace of a Hilbert space, orthogonal complements and direct sums, projection theorem, characterization of sets in Hilbert spaces whose space is dense.

Unit: 4.

Orthonormal sets and sequences, Bessel's inequality, series related to orthonormal sequences and sets, total(complete) orthonormal sets and sequences, Parseval's identity, separable Hilbert spaces.Representation of functionals on Hilbert spaces, Riesz representation theorem for bounded linear functionals on a Hilbert space, sesquilinear form, Riesz representation theorem for bounded sesquilinear forms on a Hilbert space.
Hilbert adjoint operator, its existence and uniqueness, properties of Hilbert adjoint operators, self adjoint, unitary, normal, positive and projection operators.

Books Recommended:

1. E.Kreyszig: Introductory Functional Analysis with Applications, John Wiley and Sons, New York, 1978.
2. G.F.Simmons: Introduction to Topology and Modern Analysis, McGraw Hill Book Co., New York, 1963.

3. C. Goffman and G. Pedrick: First Course in Functional Analysis, Prentice Hall of India, New Delhi, 1987.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1966.
5. L.A. Lustenik and V.J. Sobolev, Elements of Functional Analysis, Hindustan Publishing Corporation, New Delhi, 1971.
6. J.B. Conway: A Course in Functional Analysis, Springer-Verlag, 1990.
7. P.K. Jain, O.P. Ahuja and Khalil Ahmad: Functional Analysis, New Age International(P) Ltd. & Wiley Eastern Ltd., New Delhi, 1997.

MTHCC–2402: Partial Differential Equations

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Partial Differential Equations (PDE) of k^{th} order: Definition, examples and classifications. Initial value problems, Transport equations homogeneous and non-homogeneous, Radial solution of Laplace's Equation: Fundamental solutions, harmonic functions and their properties, Mean value Formula.
Poisson's equation and its solution, strong maximum principle, uniqueness, local estimates for harmonic functions, Liouville's theorem, Harnack's inequality.

Unit: 2.

Green's function and its derivation, representation formula using Green's function, symmetry of Green's function, Green's function for a half space and for a unit ball. Energy methods: uniqueness, Drichlet's principle.
Heat Equations: Physical interpretation, fundamental solution, Integral of fundamental solution, solution of initial value problem, Duhamel's principle, non-homogeneous heat equation, Mean value formula for heat equation, strong maximum principle and uniqueness. Energy methods.

Unit: 3.

Wave equation- Physical interpretation, solution for one dimentional wave equation, D'Alemberts formula and its applications, Reflection method, Solution by spherical means Euler-Poisson Darboux equation, Kirchhoff's and Poisson's formula (for $n=2, 3$ only).
Solution of non homogeneous wave equation for $n=1,3$. Energy method. Uniqueness of solution, finite propagation speed of wave equation.
Non-linear first order PDE- complete integrals, envelopes, Characteristics of (i) linear, (ii) quasilinear, (iii) fully non-linear first order partial differential equations. Hamilton Jacobi equations.

Unit: 4.

Other ways to represent solutions: Method of Separation of variables for the Hamilton Jacobi equations, Laplace, heat and wave equations, Similarity solutions (Plane and traveling waves, solitones, similarity under Scaling).

Fourier Transform, Laplace Transform, Convertible non linear into linear PDE, Cole-Hop Transform, Potential functions, Hodograph and Legendre transforms, Lagrange and Charpit methods.

Books Recommended:

1. L.C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, American Mathematical Society, 2014.
2. I.N. Snedden, Elements of Partial Differential Equations, International Edition, McGraw-Hill, Singapore, 1986.
3. John F. Partial Differential Equations, Springer-Verlag, New York, 1971.
4. T. Amarnath, An Elementary Course in Partial Differential Equations, Jones & Bartlett Publishers, 2009.
5. P. Parsad and R. Ravindran, Partial Differential Equations, New Age / International Publishers, 2005.

MTHCC–2403: Computer Programming in MATLAB

Marks (Total): 100
Total Credit: 04

Solution of the following problems based on following Numerical Methods through MATLAB :

1. Solutions of simultaneous linear equations: Gauss-elimination method; Gauss-Jordan method; Jacobi method; Gauss-Seidel method.
2. Solution of algebraic / transcendental equations: bisection method; regula-falsi method; secant method; Newton-Raphson method; Muller method; Chevyshev method.
3. Inversion of matrices: Adjoint matrix method; Jordan method.
4. Interpolation: Lagrange interpolation; Newton interpolation; Hermite interpolation.
5. Numerical differentiation: methods based on i) Interpolation, ii) finite difference operators, iii) undetermined coefficients.
6. Numerical integration: Composite methods based on trapezoidal rule, Simpson1/3 rule and 3/8 rule; Romberg method.
7. Solution of ordinary differential equations: Euler methods; Runge-Kutta methods; predictor-corrector methods.
8. Statistical problems on central tendency (mean, mode, median) and dispersion (standard variation, standard error).
9. Least square method to fit polynomial (curve) of given degree to given function (data set).
10. Plotting of special functions.

Books Recommended:

1. Numerical methods for scientific and engineering computation, (MK Jain, SRK Iyengar, RK Jain), Wiley Eastern ltd, N. Delhi (1984).
2. MATLAB Primer, Seventh Edition, (Timothy A. Davis, Kermit Sigmon), CHAPMAN & HALL/CRC

MTHCE–2404: Mathematical Aspect of Seismology

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Waves: General form of progressive waves. Harmonic waves. Plane waves. the wave equation. Principle of superposition. Progressive types solutions of wave equation. Stationary type solutions of wave equation in Cartesian, Cylindrical and Spherical coordinates systems. Equation of telegraphy. Exponential form of harmonic waves. D' Alembert's formula. Inhomogeneous wave equation. Dispersion: Group velocity, relation between phase velocity and group velocity.

Unit: 2.

Spherical waves. Expansion of a spherical wave into plane waves: Sommerfield's integral. Kirchoff's solution of the wave equation, Poissons's formula, Helmholtz's formula.
Introduction to Seismology: Earthquakes, Location of earthquakes, Causes of Earthquakes, Observation of Earthquakes, Aftershocks and Foreshocks. Earthquake magnitude, Seismic moment. Energy released by earthquakes. Interior structure of the Earth.

Unit: 3.

Reduction of equation of motion to wave equations. P and S waves and their characteristics. Polarization of plane P and S waves. Snell's law of reflection and refraction. Reflection of plane P and SV waves at a free surface. Partition of reflected energy. Reflection at critical angles.
Reflection and refraction of plane P, SV and SH waves at an interface. Special cases of Liquid-Liquid interface, Liquid-Solid interface and Solid-Solid interface.

Unit: 4.

Two dimensional Lamb's problems in an isotropic elastic solid: Area sources and Line Sources in an unlimited elastic solid. A normal force acts on the surface of a semi-infinite elastic solid, tangential forces acting on the surface of a semi-infinite elastic solid.
Three dimensional Lamb's problems in an isotropic elastic solid: Area or Volume sources and Point sources in an unlimited elastic solid. Area or Volume source and Point source on the surface of semi-infinite elastic solid. Surface waves: Rayleigh waves, Love waves and Stoneley waves.

Books Recommended:

1. C.A. Coulson and A. Jefferey, Waves, Longman, New York, 1977.
2. M. Bath, Mathematical Aspects of Seismology, Elsevier Publishing Company, 1968.

3. W.M. Ewing, W.S. Jardetzky and F. Press, Elastic Waves in Layered Media, McGraw Hill Book Company, 1957.
4. C.M.R. Fowler, The Solid Earth, Cambridge University Press, 1990
5. P.M. Shearer, Introduction to Seismology, Cambridge University Press,(UK) 1999.
6. Jose Pujol, Elastic Wave Propagation and Generation in Seismology, Cambridge Universty Press, 2003.
7. Seth Stein and Michael Wysession, An Introduction to Seismology, Earthquakes and Earth Structure, Blackwell Publishing Ltd., 2003.
8. Aki, K. and P.G. Richards, Quantitative Seismology: theory and methods, W.H. Freeman, 1980.
9. Bullen, K.E. and B.A. Bolt, An Introduction to the Theory of Seismology, Cambridge Universty Press, 1985.

MTHCE–2405: Operation Research

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Operation Research and its Scope. The linear programming (LP) Problem, General formulation of LP problem, Graphical solution of LP problems, Slack and Surplus variables. Theory and application of Simplex Method to LP problems, Charne's M-technique, Two phase method, degeneracy, alternative optima, unbounded solutions and infeasible solutions.

Unit: 2.

Duality – Definition of dual problem, relation between optimal primal and dual solutions, Dual simplex method. Basic duality theorem, Fundamental duality theorem, Existence Theorem, Complementary slackness theorem.

Unit: 3.

Transportation problems, feasible, basic feasible and optimum solutions, finding initial basic feasible solution: North West corner rule and Vogel approximation method (VAM), Optimum solution u-v method, Degeneracy, Balanced and Unbalanced problems. Assignment problem: Hungarian method, Traveling-salesman problem. Game Theory – Two-person zero sum games, Games with mixed strategies, Minimum and maximum principle, Game with saddle point, Rule of dominance, Graphical solution, Solution by linear programming.

Unit: 4.

Job Sequencing: Terminology and Notations, Principle assumptions, Solution of sequencing problem, Processing of n jobs through two machines, Johnson's Algorithm for n jobs two machines, Processing of n jobs through m machines. Unconstraint optimization, Constrained multivariables optimization, Language multiplier method, Nonlinear programming method, Kuhn Tucker conditions of optimality, Graphical method.

Books Recommended:

1. F. S. Hiller and G. J. Lieberman; Introduction to Operations Research (Sixth Edition), McGraw Hill international Edition, Industrial Engineering Series, 1995.
2. G. Hadley; Linear Programming, Narosa Publishing House, 1995.
3. G. Hadly; Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass.
4. H. A. Taha; Operation Research – An introduction, Macmillan Publishing Co. Inc., New York.
5. Kanti Swarup, P. K. Gupta and Man Mohan; Operations Research, Sultan Chand & Sons, New Delhi.

MTHCE–2406: Advanced Fluid Mechanics

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Two–dimensional inviscid incompressible flows: Stream function, Irrotational motion in two and three dimensions. Image system of a source, sink and doublet.
Complex velocity potential. Thomson-circle theorem. Two- dimensional irrotational motion produced by motion of circular cylinder.

Unit: 2.

Two dimensional motion produced by the motion of cylinder of arbitrary uniform cross section in an infinite mass of liquid at rest at infinity. Motion due to elliptic cylinder in an infinite mass of liquid. Kinetic energy of liquid contained in rotating elliptic cylinder, circulation about elliptic cylinder.
Theorem of Blasius. Theorem of Kutta and Joukowski. Kinetic energy of a cyclic and acyclic irrotational motion. Axis-symmetric flows. Stoke's stream function, Stoke's stream functions of some basic flows.

Unit: 3.

Three–dimensional motion: Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere. Equation of motion a sphere. D'Alembert's paradox, impulsive motion, initial motion of liquid contained in the intervening space between two concentric spheres.

Unit: 4.

Vortex motion and its elementary properties. Kelvin's proof of permanence. Motions due to circular and rectilinear vortices. Infinite rowes of line vortices.
Dynamical similarity. Buckingham pi-theorem. Reynolds number. Prandtl's boundary layer, boundary layer equations in two dimensions. Blasius solution Boundary layer thickness. Displacement thickness, Karman integral conditions, separation of boundary layer.

Books Recommended:

1. W.H. Besant and A.S. Ramsey, 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. Michael E.O. Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, John Wiley & Sons, 1986.
4. S. W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Ltd., New Delhi, 1976.

5. G.K. Batchelor. An Introduciton to Fluid Mechanics, Foundation Books, New Delhi, 1994.
6. A.J. Chorin and A. Marsden, A Mathematical Introduction to Fluid Dynamics Springer-Verlag, New York, 1993.
7. L.D. Landau and E.M. Lipschitz, Fluid Mechanics Pergamon Press, London, 1985.
8. H. Schlichting, Boundary Layer Theory, McGraw Hill Book Company, New York, 1979.
9. R.K. Rathy. An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
10. A.D. Young, Boundary Layers, AIAA Education Series, Washington DC, 1989.

MTHCE–2407: Boundary Value Problems

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Applications to Ordinary Differential Equations: Initial value problems. Boundary Value Problems. Dirac Delta functions. Green's function approach to reduce boundary value problems of a self-adjoint-differential equation with homogeneous boundary conditions to integral equation forms. Green's function for n^{th} order ordinary differential equation. Modified Green's function.

Unit: 2.

Applications to partial differential equations: Integral representation formulas for the solution of the Laplace and Poisson Equations. The Newtonian, single-layer and double-layer potentials, Interior and Exterior Dirichlet problems, Interior and Exterior Neumann problems. Green's function for Laplace's equation in a free space as well as in a space bounded by a ground vessel. Integral equation formulation of boundary value prolems for Laplace's equation. Poisson's Integral formula. Green's function for the space bounded by grounded two parallel plates or an infinite circular cylinder. The Helmholtz equation.

Unit: 3.

Integral Transform methods: Introduction. Fourier transform. Laplace transform. Convolution Integral. Application to Volterra Integral Equations with convolution-type Kernels. Hilbert transform.
Applications to mixed Boundary Value Problems: Two-part Boundary Value problems. Three-part-Boundary Value Problems. Generalized Three-part Boundary Value problems.

Unit: 4.

Integral equation perturbation methods: Basic procedure. Applications to Electrostatics. Low-Reynolds-Number Hydrodynamics: Steady stokes Flow. Boundary effects on Stokes flow. Longitudnal oscillations of solids in stokes Flow. Steady Rotary Stokes Flow, Rotary Oscillations in Stokes Flow. Rotary Oscillation in Stokes Flow. Oseen Flow-Translation Motion. Oseen Flow-Rotary motion Elasticity, Boundary effects, Rotation, Torsion and Rotary Oscillation problems in elasticity, crack problems in elasticity. Theory of Diffraction.

Books Recommended:

1. R.P.Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
2. S.G.Mikhlin, Linear Integral Equations (translated from Russian) Hindustan Book Agency, 1960.

3. I.N.Sneddon, Mixed Boundary Value Problems in potential theory, North Holland, 1966.
4. I. Stakgold, Boundary Value Problems of Mathematical Physics Vol.I, II, Mac. Millan, 1969.
5. M.D. Raishinghania, Integral Equations and Boundary value problems, S. Chand and Company Pvt. Ltd. 2007

MTHCE–2408: Algebraic Topology

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Fundamental Groups functions, homotopy of maps between topological spaces, homotopy equivalence, contractible and simply connected spaces, fundamental groups of S^1 and $S^1 * S^2$ etc. calculation of fundamental group of S^n, $n > 1$ using Van Kampen's theorem, fundamental groups of a topological group.

Unit: 2.

Brouder's fixed point theorem, fundamental theorem of algebra, vector fields on planar sets, Frobenius theorem for 3*3 matrices.
Covering Spaces, unique path lifting theorem, covering homotopy theorems, group of covering transformations,

Unit: 3.

criterion of lifting of maps in terms of fundamental groups, universal covering, its existence, special cases of manifolds and topological groups, Singular homology, reduced homology, Eilenberg Steenrod axioms of homology (Statement only) and their application, relation between fundamental group and first homology.

Unit: 4.

Calculation of homology of S^n, application spheres, vector fields, Mayer Victoris sequence and its application to calculation of homology of graphs, torus and compact surface of genus g, collared pairs, construction of spaces, by attaching of cells, spherical complexes with examples of S^n, r-leaved rose, torus, RP^n, CP^n etc.

Books Recommended:

1. J. R. Munkers; Topology, Prentice Hall of India.
2. M. J. Greenberg and J. R. Harper; Algebraic Topology, Addison Wesley.
3. W. S. Messey; A basic course in Algebraic Topology, Springer.
4. A. Hatcher; Algebraic Topology, Cambridge University Press.

MTHCE–2409: Analytic Number Theory

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Arithmetical functions , Mobius function, Euler totient function, relation connecting Mobius function and Euler totient function, Product formula for Euler totient function, Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, Mangoldt function, multiplicative functions, Multiplicative functions and Dirichlet multiplication. Inverse of completely multiplicative function, Liouville's function, divisor function, generalized convolutions, Formal power-series, Bell series of an arithmetical function, Bell series and Dirichlet multiplication, Derivatives of arithmetical functions, Selberg identity. Asymptotic equality of functions, Euler's summation formula, some elementary asymptotic formulas, average order of divisor functions, average order of Euler totient function.

Unit: 2.

Application to the distribution of lattice points visible from the origin, average order of Mobius function and Mangoldt function, Partial sums of a Dirichlet Product, applications to Mobius function and Mangoldt function, Legendre's identity, another identity for the partial sums of a Dirichlet product, Chebyshev's functions, Abel's identity, some equivalent forms of the prime number theorem. Inequalities for $\pi(n)$ and P^n. Shapiro's Tauberian theorem.

Applications of Shapiro's theorem. An asymptotic formula for the partial sums $\sum_{p\le x}\left(\frac{1}{p}\right)$. Partial sums of the Mobius function. Brief sketch of an elementary proof of the prime number theorem; Selberg's asymptotic formula.

Unit: 3.

Elementary properties of groups, construction of subgroups, characters of finite abelian groups, the character group, orthogonality relations for characters, Dirichlet characters, Sums-involving Dirichlet characters, Nonvanishing of $L(1,\chi)$ for real nonprincipal χ.
Dirichlet's theorem for primes of the form $4n-1$ and $4n+1$. Dirichlet's theorem. Functions periodic modulo K, Existence of finite Fourier series for periodic arithmetical functions.

Unit: 4.

Ramanujan's sum and generalizations, multiplicative properties of the sums $S^k(n)$. Gauss sums associated with Dirichlet characters, Dirichlet characters with nonvanishing Gauss sums, Induced moduli and primitive characters, properties of induced moduli conductor of a character. Primitive characters and separable Gauss sums, Finite fourier series of the Dirichlet characters, Polya's inequality for the partial sums of primitive characters.

Books Recommended:

1. Tom M. Apostol, Introduction to Analytic Number Theory.

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MTHCE–2410: Algebraic Coding Theory

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Block Codes. Minimum distance of a code. Decoding principle of maximum likelihood. Binary error detecting and error correcting codes. Group codes. Minimum distance of a group code (m, m+1) parity check code. Double and triple repition codes. Matrix codes. Generator and parity check matrices. Dual codes. Polynomial codes. Exponent of a polynomial over the binary field. Binary representation of a number. Hamming codes. Minimum distance of a Hamming code.

Unit: 2.

Finite fields. Construction of finite fields. Primitive element of a finite field. Irreducibility of polynomials over finite fields. Irreducible polynomials over finite fields. Primitive polynomials over finite fields. Automorphism group of $GF(q^n)$. Normal basis of $GF(q^n)$. The number of irreducible polynomials over a finite field. The order of an irreducible polynomial. Generator polynomial of a Bose-Chaudhuri-Hocqhenghem codes (BCH codes) construction of BCH codes over finite fields.

Unit: 3.

Linear codes. Generator matrices of linear codes. Equivalent codes and permutation matrices. Relation between generator and parity-check matrix of a linear codes over a finite field. Dual code of a linear code. Self dual codes. Weight distribution of a linear code. Weight enumerator of a linear code. Hadamard transform. Macwilliams identity for binary linear codes.
Maximum distance separable codes. (MDS codes). Examples of MDS codes. Characterization of MDS codes in terms of generator and parity check matrices. Dual code of a MDS code. Trivial MDS codes. Weight distribution of a MDS code. Number of code words of minimum distance d in a MDS code. Reed solomon codes.

Unit: 4.

Hadamard matrices. Existence of a Hadamard matrix of order n. Hadamard codes from Hadamard matrices Cyclic codes. Generator polynomial of a cyclic code. Check polynomial of a cyclic code. Equivalent code and dual code of a cyclic code. Idempotent generator of a cyclic code. Hamming and BCH codes as cyclic codes. Perfect codes. The Gilbert-varsha-move and Plotkin bounds. Self dual binary cyclic codes.

Books Recommended:

1. L.R. Vermani. Elements of Algebraic Coding Theory (Chapman and Hall Mathematics).
2. Steven Roman. Coding and Information Theory (Springer Verlag)

MTHCE–2411: Control Theory

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.
Concept of control systems, definition and examples, open loop and closed loop systems. Continuous time systems and Laplace transformations, Discrete time systems and z-transforms, Transfer functions. Solution of uncontrolled systems (spectral form, exponential matrix, repeated roots).

Unit: 2.
Solution of controlled systems, time varying systems, discrete time systems, relationship between state space and classical forms. Linear Control systems, controllability, observability, controllability and polynomials, linear feedback, state observers, realization of constant systems and time varying systems.

Unit: 3.
Stability, definitions, algebraic criterion for stability, Nyquist criterion, Lyapunov theory, application of Lyapunov theory to linear systems, construction of Lyapunov functions. Variable gradient method and Zubov'method, stability and control.

Unit: 4.
Optimal Control: definition, performance indices and constraints, variational approach to optimal control systems, linear quadratic optimal control systems: regulator and tacking problems, matrix differential Riccati equation, Pontryagin minimum principle, optimal control using dynamic programming, Hamilton Jacobi Bellman equation.

Books Recommended:

1. S. Barnett: Introduction to mathematical control theory, Clarendon press.
2. D. S. Naidu: Optimal control systems, CRC press.

MTHCE–2412: Bio-Mechanics

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.
Newton's equations of motion. Mathematical modeling. Continuum approach.

Unit: 2.
Segmental Movement and Vibrations. External Flow: Fluid Dynamic Forces Acting on Moving Bodies.

Unit: 3.
Flying and Swimming. Blood Flow in Heart, Lung, Arteries, and Veins. Micro and Macrocirculation. Respiratory Gas Flow.

Unit: 4.
Description of Internal Deformation and Forces. Stress, Strain, and Stability of Organs.

Books Recommended:

1. Y. C. Fung: Biomechanics, Springer-Verlag, New York Inc., 1990.

MTHCE–2413: Algebraic Number Theory

Marks (Theory): 70
Marks (Internal Assessment): 30

Marks (Total): 100
Time: 03 Hours
Total Credit: 04

Note: -

The examiner is required to set nine questions in all.
The first question will be compulsory consisting of seven short questions (2 marks each) covering the whole syllabus.
In addition, eight more questions will be set unit-wise comprising two questions from each of the four units. The students shall be required to attempt five questions in all selecting one question from each unit including compulsory question.

Unit: 1.

Algebraic numbers and algebraic integers. Transcendental Numbers. Liouville's Theorem for real Algebraic numbers. Thue Theorem and Roth's theorem (statement only). Algebraic numberfield K. Theorem of Primitive elements. Liouville's Theorem for complex algebraic numbers. Minimal polynomial of an algebraic integer. Primitive m-th roots of unity. Cyclotomic Polynomials. Norm and trace of algebraic numbers and algebraic integers. Bilinear form on algebraic number field K.

Unit: 2.

Integral basis and discriminant of an algebraic number field. Index of an element of K. Ring O_k of algebraic integers of an algebraic number field K. Ideals in the ring of algebraic number field K. Integrally closed domains. Dedekind domains. Fractional ideals of K. Factorization of ideals as a product of prime ideals in the ring of algebraic integers of an algebraic number field K. G.C.D. and L.C.M. of ideals in O_k. Chinese Remainder theorem.

Unit: 3.

Different of an algebraic number field K. Dedekind theorem. Euclidean rings. Hurwitz Lemma and Hurwitz constant. Equivalent fractional ideals. Ideal class group. Finiteness of the ideal class group. Class number of the algebraic number field K.

Unit: 4.

Diophantine equations Minkowski's bound. Quadratic reciprocity Legendre Symbol. Gauss sums. Law of quadratic reciprocity. Quadratic fields. Primes in special progression.

Books Recommended:

1. Jody Esmonde and M.Ram Murty, Problems in Algebraic Number Theory (Springer Verlag, 1998).
2. Paulo Ribenboim, R. Narasimhan, S. Raghavan, Algebraic Numbers, Algebraic Number Theory and Mathematical Pamphlets-I. Tata Institute of Fundamental Research(1966).