Chaudhary Ranbir Singh University, Jind

Scheme of Examination of M.Sc. Mathematics, Semester – IV
Session 2017-18

Compulsory Papers:

Paper Code	Nomenclature	External Theory Exam. Marks	Internal Assessment Marks	Max. Marks	Examination Hours
MM-506	Functional Analysis - II	80	20	100	3 Hours
MM-507	Classical Mechanics	80	20	100	3 Hours

Optional Papers: A candidate can opt one optional paper from MM-508 opt (i) to opt (iv). Similarly one paper will be opted each from MM-509 opt (i) to opt (iv) and MM-510 opt (i) to opt (iv)

Paper Code	Nomenclature	External Theory Exam. Marks	Internal Assessment Marks	Max. Marks	Examination Hours
MM-508 (Opt. (i)	Mechanics of Solids	80	20	100	3 Hours
MM-508 **(Opt. (ii)**	Difference Equations-II	80	20	100	3 Hours
MM-508 **(Opt. (iii)**	Algebraic Number Theory	80	20	100	3 Hours
MM-508 **(Opt. (iv)**	Advanced Complex Analysis	80	20	100	3 Hours
MM-509 (Opt. (i)	Fluid Mechanics-II	80	20	100	3 Hours
MM-509 **(Opt. (ii)**	Boundary Value Problems	80	20	100	3 Hours
MM-509 **(Opt. (iii)**	Non-Commutative Rings	80	20	100	3 Hours
MM-509 **(Opt. (iv)**	Discrete Mathematics	80	20	100	3 Hours
MM-510 (Opt. (i)	Mathematical Aspects of Seismology	80	20	100	3 Hours
MM-510 **(Opt. (ii)**	Dynamical Systems	80	20	100	3 Hours

Paper Code	Nomenclature	External Theory Exam. Marks	Internal Assessment Marks	Max. Marks	Examination Hours
MM-510 (Opt. (iii)	Operational Research	80	20	100	3 Hours
MM-510 (Opt. (iv)	Fuzzy Sets & Applications-II	80	20	100	3 Hours
MM-511	Matlab	--	--	100	4 Hours

SEMESTER - IV

MM-506 : Functional Analysis - II

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks : 80
Internal Assessment Marks : 20)

Note : The question paper will consist of **five** Sections. Each of the first four Sections will contain **two** questions from Section **I , II , III , IV** respectively and the students shall be asked to attempt **one** question from each Section. Section five will contain **eight to ten** short answer type questions without any internal choice covering the entire syllabus and shall be **compulsory**.

Section-I (2 Questions) Signed measure, Hahn decomposition theorem, Jordan decomposition theorem, Mutually signed measure, Radon - Nikodym theorem Lebesgue decomposition, Lebesgue - Stieltjes integral, Product measures, Fubini's theorem.

Section-II (2 Questions) Baire sets, Baire measure continuous functions with compact support, Regularity of measures on locally compact spaces, Riesz-Markoff theorem **Hilbert Spaces** Inner product spaces, Hilbert spaces, Schwarz's inequality, Hilbert space as normed linear space.

Section-III (2 Questions) Convex sets in Hilbert spaces, Projection theorem Orthonormal sets, Bessel's inequality, Parseval's identity, conjugate of a Hilbert space, Riesz representation theorem in Hilbert spaces.

Section-IV (2 Questions) Adjoint of an operator on a Hilbert space, Reflexivity of Hilbert space, Self-adjoint operators, Positive and projection operators, Normal and Sectionary operators, Projections on Hilbert space, Spectral theorem on finite dimensional space.

Books Recommended

1. H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4th Edition 1993.
2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley.
3. S.K. Berberian, Measure and Integration, Chelsea Publishing Company, New York, 1965.
4. G. Bachman and L. Narici, Functional Analysis, Academic Press, 1966.
5. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.

SEMESTER - IV

MM-507 : Classical Mechanics

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks : 80
+ Internal Assessment Marks : 20)

Note : The question paper will consist of **five** Sections. Each of the first four Sections will contain **two** questions from Section **I , II , III , IV** respectively and the students shall be asked to attempt **one** question from each Section. Section five will contain **eight to ten** short answer type questions without any internal choice covering the entire syllabus and shall be **compulsory.**

Section –I(2 Question) Free & constrained systems, constraints and their classification, holonomic and non-holonomic systems, degree of freedom and generalised coordinates, virtual displacement and virtual work, statement of principle of virtual work (PVW), possible velocity and possible acceleration, D" Alembert"s principle, **Lagrangian Formulation :** Ideal constraints, general equation of dynamics for ideal constraints, Lagrange"s equations of the first kind.

Section –II(2 Question) Independent coordinates and generalized forces, Lagrange"s equations of the second kind, generalized velocities and accelerations. Uniqueness of solution, variation of total energy for conservative fields. Lagrange"s variable and Lagrangian function L(t, qi.), Lagrange"s equations for potential forces, generalized momenta pi , Hamiltonian variable and Hamiltonian function H(t, qi, pi), Donkin"s theorem, ignorable coordinates.

Section -III(2 Question) Hamilton canonical equations, Routh variables and Routh function R, Routh"s equations, Poisson Brackets and their simple properties, Poisson"s identity, Jacobi – Poisson theorem. Hamilton action and Hamilton"s principle, Poincare – Carton integral invariant, Whittaker"s equations, Jacobi"s equations, Lagrangian action and the principle of least action.

Section -IV(2 Question) Canonical transformation, necessary and sufficient condition for a canonical transformation, univalent Canonical transformation, free canonical transformation, Hamilton-Jacobi equation, Jacobi theorem, method of separation of 42variables in HJ equation.

Lagrange brackets, necessary and sufficient conditions of canonical character of a transformation in terms of Lagrange brackets. Jacobian matrix of a canonical transformation, conditions of canonicity of a transformation in terms of Poison brackets, invariance of Poisson Brackets under canonical transformation.

Books Recommended

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

SEMESTER-IV

MM-508 (opt. i) Mechanics of Solids

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory question will consist of eight parts and will be distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two Questions)

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 $\phi(z)$ and $\psi(z)$. First and second boundary-value problems in plane elasticity. Existence and uniqueness of the solutions.
(Section 65-74 of the book by I.S. Sokolnikoff)

SECTION -II (Two Questions)

Waves : Propagation of waves in an isotropic elastic solid medium. Waves of dilatation and distortion. Plane waves. Elastic surface waves : Rayleigh waves and Love waves.
Extension : Extension of beams, bending of beams by own weight and terminal couples.: bending of rectangular beams
(Section 204 of A.E.H. Love. Sections 7.7-8, 10 of Y.C. Fung; Chapter 4, Sections 30 to 32 and 57 of book by I.S. Sokolnikoff).

SECTION -III (Two Questions)

Torsion : Torsion of cylindrical bars; Torsional rigidity. Torsion and stress functions. Lines of shearing stress. Torsion of anisotropic beams. Simple problems related to circle, ellipse and equilateral triangle.
(Chapter 4 Sections 33 to 38 and 51 of the book, I.S. Sokolnikoff. Section 221 of A.E.H. Love).

SECTION -IV(Two Questions)

Variational methods : Theorems of minimum potential energy. Theorems of minimum complementary energy. Reciprocal theorem of Betti and Rayleigh. Deflection of elastic string cental line of a beam and elastic membrane. Solution of Euler's equation by Ritz, Galerkin and Kantorovich methods.
(Chapter 7: Sections 107-110, 112, 113, 115 & 117 of I.S. Sokolnikoff).

Books:

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. Timeshenki and N. Goodier, Theory of Elasticity, McGraw Hill, New York, 1970.
6. I.H. Shames, Introduction to Solid Mechanics, Prentice Hall, New Delh, 1975.

SEMESTER-IV

MM-508 (opt. ii) Difference Equations-II

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory question will consist of eight parts and will be distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two Questions)

The self-adjoint second order linear equations: Introduction. Lagrange identity. Green's Theorem. Liouville's formula. Polya Factorization Theorem and application. Cauchy function. variation of constants formula

Sturmian Theory : Sturm separation theorem and examples. The Riccati Equation.

SECTION-II (Two Questions)

Sturm comparison Theorem. Oscillation.

The Sturm-Liouville problem : Introduction. eigen functions and eigen values of Sturm-Liouville problem. Finite Fourier analysis. Non-homogeneous problem. Rayleigh's inequality.

SECTION-III (Two Questions)

Green's functions and Boundary Value Problems, Disconjugacy. B.V.P. for non-linear equation : Introduction. contraction mapping theorem. Lipschitz condition & examples. Existence of solutions. some basic theorem and examples. B.V.P. for Differential Equations.

SECTION-IV (Two Questions)

Discrete calculus of variation. Introduction. Necessary condition for the simplest variational problem of local extremum. Euler- Lagrange equation. Sufficient condition and Disconjugacy. Sturm comparison Theorem. Weiesstrass Summation formula.

Partial Differential Equations. Discretization of Partial Differential Equations. Solution of Partial Differential Equation.

Recommend Text:

W.G. Kelley and A.C. Peterson: Difference Equations: An introduction with Applications. Academic Press. Harcourt, 1991. (Relevant portions of chapters 6-10.)

Reference Book:

Calvin Ahlbrandt & Allan C. Peterson, Discreet Hamiltonian systems. Difference Equations. Continued Fractions & Ricati Equation. Kluwer Botson. 1996.

Books:

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. Timeshenki and N. Goodier, Theory of Elasticity, McGraw Hill, New York, 1970.
6. I.H. Shames, Introduction to Solid Mechanics, Prentice Hall, New Delhi, 1975.

SEMESTER-IV

MM-508 (opt. iii) Algebraic Number Theory

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory question will consist of eight parts and will be distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two Questions)

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.

SECTION-II (Two Questions)

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.

SECTION-III (Two Questions)

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. Diophantine equations Minkowski's bound.

SECTION-IV (Two Questions)

Quadratic reciprocity Legendre Symbol. Gauss sums. Law of quadratic reciprocity. Quadratic fields. Primes in special progression.

Recommended Text:

Jody Esmonde and M.Ram Murty — Problems in Algebraic Number Theory (Springer Verlag, 1998)

Reference Books:

1. Paulo Ribenboim — Algebraic Numbers
2. R. Narasimhan and S. Raghavan — Algebraic Number Theory Mathematical Pamphlets-4. Tata Institute of Fundamental Research(1966)

SEMESTER - IV

MM508 (opt. iv): Advanced Complex Analysis

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks : 80
+Internal Assessment Marks : 20)

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

Section - I

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

Section - II

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

Section - III

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

Section - IV

The range of an analytic function, Bloch theorem, Schottky theorem, Little Picard theorem, Montel Caratheodory theorem, Great Picard theorem, Univalent functions, Bieberbach conjecture(Statement only) and the "1/4 theorem".

Books Recommended

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

H.S. kasana, Complex Variable Theory and Applications, PHI Learning Private Ltd, 2011.

SEMESTER- IV

MM-509 (opt. i) Fluid Mechanics -II

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory question will consist of eight parts and will be distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two Questions)

Fundamental Equations: Derivation of the equations of continuity and equation of motion in cylindrical and spherical coordinates.

Two-dimentional inviscid incompressible flows. Stream function : Irrotatonal motion in two dimensions. Complex velocity potential. Sources. sinks. doublets and their images Thomson circle theorem. Two- dimensional irrotational motion produced by motion of circular cylinder.

SECTION-II (Two Questions)

Two dimensional motion : 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. Axisymmetric flows. Stoke's stream function .Stoke's stream functions of some basic flows.

SECTION-III (Two Questions)

Three -dimential motion : Motion of a sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere. Equation of motion a sphere. Alembert's paradox. impulsive motion. initial motion of liquid contained in the intervening space between two concentric spheres. Vortex motion and its elementary properties. Kelvin's proof of permanence. Motions due to circular and rectilinear vortices. Infinite rowes of line vortices.

SECTION-IV (Two Questions)

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 :

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. 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. S. w. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Ltd., New Delhi, 1976 event

SEMESTER-IV

MM-509 (opt.ii) Boundary Value Problems

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory question will consist of eight parts and will be distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two Questions)

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.

(Relevant portions from the Chapter 5 of the book "Linear Integral Equation. Theory and Techniques by R.P.Kanwal").

SECTION-II (Two Questions)

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.

(Relevant portions from the Chapter 6 of the book "Linear Integral Equation. Theory and Techniques by R.P.Kanwal").

SECTION-III (Two Questions)

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.

(Relevant portions from the Chapter 9 and 10 of the book "Linear Integral Equation. Theory and Techniques by R.P.Kanwal").

SECTION-IV (Two Questions)

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.

(Relevant portions from the Chapter 11 of the book "Linear Integral Equation, Theory and Techniques by R.P Kanwal")

References:

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. Pundir and Pundir, Integral equations and Boundary value problems, Pragati Prakashan, Meerut.

SEMESTER-IV

MM-509 (opt. iii) Non-Commutative Rings

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory question will consist of eight parts and will be distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two Questions)

Basic terminology and examples of non-commutative rings i.e. Hurwitz's ring of integral quaternions. Free k-rings. Rings with generators and relations. Hilbert's Twist. Differential polynomial rings. Group rings. Skew group rings. Triangular rings. D.C.C. and A.C.C. in triangular rings. Dedekind finite rings. Simple and semi-simple modules and rings. Spliting homomorphisms. Projective and Injective modules. (Section 1.1 to 1.26 and Section 2.1 to 2.9 of the book given at Sr. No. 1).

SECTION-II (Two Questions)

Ideals of matrix ring $M_n(R)$. Structure of semi simple rings. Wedderburn-Artin Theorem. Schur's Lemma. Minimal ideals. Indecomposable ideals. Inner derivation. δ δ-simple rings. Amitsur Theorem on non-inner derivations. Jacobson radical of a ring. R.Annihilator ideal of an R-module M. Jacobson semi-simple rings. Nil and Nilpotent ideals. Hopkins-Levitzki Theorem. Jacobson radical of the matrix ring $M_n(R)$. Amitsur Theorem on radicals. Nakayama's Lemma. Von Neumann regular rings. E. Snapper's Theorem. Amitsur Theorem on radicals of polynomial rings. (Section 3.1 to 3.19, Sections 4.1 to 4.27, Section 5.1 to 5.10 of the book given at Sr. No. 1).

SECTION-III (Two Questions)

Prime and semi-prime ideals. m-systems. Prime and semi-prime rings. Lower and upper nil radical of a ring R. Amitsur theorem on nil radical of polynomial rings. Brauer's Lemma. Levitzki theorem on nil radicals. Primitive and semi-primitive rings. Left and right primitive ideals of a ring R. Density Theorem. Structure theorem for left primitive rings. (Section 10.1 to 10.30, Section 11.1 to 11.20 of the book given at Sr. No. 1).

SECTION-IV (Two Questions)

Sub-direct products of rings. Subdirectly reducible and irreducible rings. Birchoff's Theorem. Reduced rings. G.Shin's Theorem. Commutativity Theorems of Jacobson. Jacobson-Herstein and Herstein Kaplansky. Division rings. Wedderburn's Little Theorem. Herstein's Lemma. Jacobson and Frobenius Theorem. Cartan-Brauer-Hua Theorem. Herstein's Theorem. (Sections 12.1 to 12.11 and Sections 13.1 to 13.26 of the book given at Sr. No. 1).

Recommended Book:

1. T.Y. Lam — A First Course in Noncommutive Rings. (Springer Verlag 1990)
2. I.N. Herstein — Non-Commutative Rings carus monographs in Mathematics Vol.15. Math Asso. of America 1968.

SEMESTER - IV

MM-509(Opt. iv): Discrete Mathematics

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks : 80
+ Internal Assessment Marks : 20)

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

Section - I

Recurrence Relations and Generating Functions, Some number sequences, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Generating functions, Recurrences and generating functions, Exponential generating functions.

Section - II

Statements Symbolic Representation and Tautologies, Quantifiers, Predicates and validity,

Prepositional Logic. Lattices as partially ordered sets, their properties, Lattices as Algebraic systems. Sub lattices, Direct products and Homomorphism, Some special lattices e.g. complete, Complemented and Distributive Lattices.

Section - III

Boolean Algebras as Lattices, Various Boolean Identities, The switching Algebra. Example, Subalgebras, Direct Products and Homomorphism, Joint-irreducible elements, Atoms and Minterms, Boolean forms and their equivalence, Minterm Boolean forms,

Sum of Products, Cononical forms, Minimization of Boolean functions, Applications of Boolean Algebra to Switching Theory (using AND, OR and NOT gates.) The Karnaugh method.

Section - IV

Finite state Machines and their Transition table diagrams, Equivalence of Finite State, Machines, Reduced Machines, Homomorphism. Finite automata, Acceptors, Non-deterministic, Finite Automata and equivalence of its power to that of deterministic Finite automata, Moore and Mealy Machines.

Grammars and Language: Phrase-Structure Grammars, Requiting rules, Derivation, Sentential forms, Language generated by a Grammar, Regular, Context -Free and context sensitive grammars and Languages, Regular sets, Regular Expressions and the pumping Lemma.

Books Recommended:

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition
2. Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co, New York
3. John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition
4. J.P. Tremblay, R. Manohar, "Discrete mathematical structures with applications to computer science", Tata-McGraw Hill Education Pvt Ltd.
5. J.E. Hopcraft and J.D.Ullman, Introduction to Automata Theory, Langauages and Computation, Narosa Publishing House.
6. M. K. Das, Discrete Mathematical Structures for Computer Scientists and Engineers, Narosa Publishing House.
7. C. L. Liu and D.P.Mohapatra, Elements of Discrete Mathematics- A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

SEMESTER-IV

MM-510 (opt. i) Mathematical Aspects of Seismology

Examination Hours : 3 Hours

Max. Marks : 100

(External Theory Exam. Marks:80 + Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory question will consist of eight parts and will be distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two Questions)

General form of progressive waves, Harmonic waves, Plane waves, the wave equation. Principle of superposition. Special types of solutions: Progressive and Stationary type solutions of wave equation. 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.

(Relevant articles from the book "*Waves*" by Coulson & Jefferey)

SECTION-II (Two Questions)

Reduction of equation of motion to wave equations. P and S waves and their characteristics. Polarisation 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 reflection of plane P,SV and SH waves at an interface. Special cases of Liquid-Liquid interface, Liquid-Solid interface and Solid-Solid interface. Rayleigh waves, Love waves and Stoneley waves. (Relevant articles from the book, "*Elastic waves in Layered Media*" by Ewing et al).

SECTION-III (Two Questions)

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 sources and Point sources in an unlimited elastic solid, Area source and Point source on the surface of semi-infinite elastic solid.

Haskell matrix method for Love waves in multilayered medium.

(Relevant articles from the book "*Mathematical Aspects of Seismology*" by Markus Bath).

SECTION-IV (Two Questions)

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.

(Relevant articles from the book "*Mathematical Aspects of Seismology*" by Markus Bath)

Introduction to Seismology. Location of earthquakes, Aftershocks and Foreshocks. Earthquake magnitude. Seismic moment. Energy released by earthquakes, observation of earthquakes, interior of the earth.

(Relevant articles from the book "*The Solid Earth*" by C.M.R.Fowler)

References:

1. P.M.Shearer, *Introduction to Seismology*, Cambridge University Press,(UK) 1999.
2. C.M.R.Fowler, *The Solid Earth*, Cambridge University Press, 1990.
3. C.A.Coulson and A.Jefferey, *Waves*, Longman, New York, 1977.
4. M.Bath, *Mathematical Aspects of Seismology*, Elsevier Publishing Company, 1968.
5. W.M.Ewing, W.S.Jardetzky and F.Press, *Elastic Waves in Layered Media*, McGraw Hill Book Company, 1957.

SEMESTER-IV

MM-510 (opt. ii) Dynamical Systems

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to two questions from each section and one compulsory question consisting of eight parts and distributed over the whole syllabus. An examinee is required to attempt one question from each section and the compulsory question.

Section-I

Orbit of a map, fixed point; Periodic point; Circular map, Configuration space & phase space.

Section-II

Origin of bifurcation; Stability of a fixed point, equilibrium point; Concept of limit cycle & torus; Hyperbolicity; Quadratic map, Feigenbaum's universal constant

Section-III

Turning point, transcritical, pitch work; Hopf bifurcation; Period doubling phenomenon Non-linear oscillators

Section-IV

Conservative system; Hamiltonian system; Various types of oscillators; Solutions of non-linear differential equations

Books :

1. D.K. Arrowosmith, Introduction to Dynamical Systems, CUP, 1990
2. R.L Davaney, An Introduction to Chaotic Dynamical Systems, Addison-Wesley, 1989
3. P.G. Drazin, Nonlinear System, CUP, 1993
4. V.I Arnold, Nonlinear Systems III-Mathematical Aspects of Classical and Celestial Mechanics, Springer-Verlag, 1992.
5. V.I Arnold, Nonlinear Systems V-Bifurcation Theory and Catastrophe Theory Springer-Verlag, 1992.

SEMESTER - IV

MM-510(Opt.iii) : Operations Research Techniques

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks : 80
+Internal Assessment Marks : 20)

Section - I (2 Questions) Operations Research: Origin, definition, methodology and scope. Linear Programming: Formulation and solution of linear programming problems by graphical and simplex methods, Big - M and two phase methods, Degeneracy, Duality in linear programming.

Section - II (2 Questions) Transportation Problems: Basic feasible solutions, optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, transhipment problem. Assignment problems: Solution by Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew assignment problems.

Section - III (2 Questions) Queuing models: Basic components of a queuing system, General birth-death equations, steady-state solution of Markovian queuing models with single and multiple servers (M/M/1, M/M/C, M/M/1/k, M/MC/k) Inventory control models: Economic order quantity(EOQ) model with uniform demand and with different rates of demands in different cycles, EOQ when shortages are allowed, EOQ with uniform replenishment, Inventory control with price breaks.

Section - IV (2 Questions) Game Theory : Two person zero sum game, Game with saddle points, the rule of dominance; Algebraic, graphical and linear programming methods for solving mixed strategy games. Sequencing problems: Processing of n jobs through 2 machines, n jobs through 3 machines, 2 jobs through m machines, n jobs through m machines.

Note : The question paper will consist of **five** Sections. Each of the first four Sections will contain **two** questions from Section **I , II , III , IV** respectively and the students shall be asked to attempt **one** question from each Section. Section five will contain **eight to ten** short answer type questions without any internal choice covering the entire syllabus and shall be **compulsory**.

Books recommended :

1. Taha, H.A., Operation Research-An introducton, Printice Hall of India.
2. Gupta, P.K. and Hira, D.S., Operations Research, S. Chand & Co.
3. Sharma, S.D., Operation Research, Kedar Nath Ram Nath Publications.
4. Sharma, J.K., Mathematical Model in Operation Research, Tata McGraw Hill.

SEMESTER-IV

MM-510 (opt. iv) Fuzzy Sets and Applications-II

Examination Hours : 3 Hours
Max. Marks : 100
(External Theory Exam. Marks:80
+ Internal Assessment Marks:20)

NOTE : The examiner is requested to set nine questions in all taking two questions from each section and one compulsory question. The compulsory questions will consist of eight parts and distributed over the whole syllabus. The candidate is required to attempt five questions selecting at least one from each section and the compulsory question.

SECTION-I (Two questions)

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, degree of compatibility, degree of possibility, relation with possibility distribution function and possibility measure, example of possibility distribution for fuzzy proposition Possibility theory versus probability theory, characterization of relationship between belief measures and probability measures, probability distribution function, joint probability distribution function, marginal probability distributions, noninteractive, independent marginal distributions (Scope as in the relevant parts of Chapter 7 of the book mentioned at the end.)

SECTION-II (Two questions)

Fuzzy Logic: An overview of classical logic, about logic functions of two variables Multivalued logics, about three-valued logic, n-valued logic, degrees of truth, definition of primitives, Fuzzy propositions, classification, canonical forms, relation with possibility distribution function, Fuzzy Quantifiers, their two kinds, relation with possibility distribution function, Linguistic hedges, as a unary operation and modifiers, properties Inference from conditional fuzzy propositions, relations with characteristic and membership functions, Compositional rule of inference, modus ponens and tollens, hypothetical syllogism, inference from conditional and qualified propositions equivalence of the method of truth-value restrictions to the generalized modus ponens (Scope as in the relevant parts of sections 8.1 to 8.7 of Chapter 8 of the book mentioned at the end.)

SECTION-III (Two questions)

Approximate reasoning. An overview of fuzzy expert system. Fuzzy implications as functions and operators. S-implications. R-implications. Gödel implication. QL-implications. Zadeh implication. examples. properties. combinations. axioms of fuzzy implications and characterization (only statement).

Selection of fuzzy implications. selection of approximate fuzzy implications to reasoning with unqualified fuzzy propositions. relation with compositional rule of inference. modus ponens and tollens.hypothetical syllogism Multiconditional approximate reasoning. method of interpolation. an illustration of the method for two if-then rules. as special case of compositional rule of inference and related results of fuzzy sets involved. The role of fuzzy relation equations. necessary and sufficient condition for a solution of the system of fuzzy relation equations for a fuzzy relation. its implications.(Scope as in the relevant parts of sections 11.1 to 11.5 of Chapter 11 of the book mentioned at the end .)

SECTION-IV (Two questions)

An introduction to fuzzy control: Fuzzy controllers. its modules. Fuzzy rule base. Fuzzy inference enzine. fuzzification and defuzzifications. steps of design of fuzzy controllers. defuzzification method. center of area method. center of maxima method and mean of maxima method. (Scope as in the relevant part of section 12.2 of chapter 12 of the book mentioned at the end .)

Decision -making in Fuzzy environment. Individual decision-making. fuzzy decision. simple examples. idea of weighting coefficients. Multiperson decision-making. fuzzy group decision. examples. Multicriteria decision-making. matrix representation of fuzzy relation. convertion to single-criterion decision. examples. Multistage decision-making. idea of principle of optimality. Fuzzy ranking methods. Hamming distance. priority set. examples. Fuzzy linear programming. two different methods one with only one side involving fuzzy numbers and other where only the coefficients of constraint matrix are fuzzy numbers. (Scope as in the relevant parts of Chapter 15 of the book mentioned at the end .)

Book :

G. J. Klir and B. Yuan Fuzzy Sets and Fuzzy Logic Theory and Appplications.

Semester-IV

Paper MM-511 : Practical-IV

Time : 4 hours
Max. Marks : 100

Part-A : Problem Solving

In this part, problem solving techniques based on papers MM-507 to MM-511 will be taught.

Part-B : Problem solving through MATLAB

Computer programs based on following Numerical Methods.

1. Solutions of simultaneous linear equations.
2. Solution of algebraic / transcendental equations
3. Inversion of matrices
4. Numerical differentiation and integration
5. Solution of ordinary differential equations
6. Statistical problems on central tendency and dispersion
7. Fitting of curves by least square method.

Note :- Every student will have to maintain practical record on a file of problems solved and the computer programs done during practical class-work. Examination will be conducted through a question paper set jointly by the external and internal examiners. The question paper will consists of questions on problem solving techniques/algorithm and computer programs. An examinee will be asked to write the solutions in the answer book. An examinee will be asked to run (execute) one or more computer programs on a computer. Evaluation will be made on the basis of the examinee's performance in written solutions/programs, execution of computer programs and viva-voce examination.