# Scheme of Examination for M.Sc. Mathematics

w.e.f 2011-12

## Semester – I

<table>
<thead>
<tr>
<th>Paper Code</th>
<th>Nomenclature</th>
<th>External Theory Exam. Marks</th>
<th>Internal Assessment Marks</th>
<th>Max. Marks</th>
<th>Examination Hours</th>
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</thead>
<tbody>
<tr>
<td>MM-401</td>
<td>Advanced Abstract Algebra – I</td>
<td>80</td>
<td>20</td>
<td>100</td>
<td>3 Hours</td>
</tr>
<tr>
<td>MM-402</td>
<td>Real Analysis – I</td>
<td>80</td>
<td>20</td>
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<tr>
<td>MM-403</td>
<td>Topology</td>
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<td>MM-404</td>
<td>Complex Analysis – I</td>
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<tr>
<td>MM-405</td>
<td>Differential Equations – I</td>
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<td>MM-406</td>
<td>Practical-I</td>
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## Semester – II

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<tr>
<td>MM-407</td>
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<td>MM-409</td>
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<td>MM-412</td>
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## Scheme of Examination for M.Sc. Mathematics

### Semester – III

### Compulsory Papers:

<table>
<thead>
<tr>
<th>Paper Code</th>
<th>Nomenclature</th>
<th>External Theory Exam. Marks</th>
<th>Internal Assessment Marks</th>
<th>Max. Marks</th>
<th>Examination Hours</th>
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<tbody>
<tr>
<td>MM-501</td>
<td>Functional Analysis</td>
<td>80</td>
<td>20</td>
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<td>MM-502</td>
<td>Analytical Mechanics and Calculus of Variations</td>
<td>80</td>
<td>20</td>
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### Optional Papers: A student can opt one optional paper from MM-503 opt (i) to opt (iv). Similarly one paper will be opted each from MM-504 opt (i) to opt (iv) and MM-505 opt (i) to (iv)

<table>
<thead>
<tr>
<th>Paper Code</th>
<th>Nomenclature</th>
<th>External Theory Exam. Marks</th>
<th>Internal Assessment Marks</th>
<th>Max. Marks</th>
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<tbody>
<tr>
<td>MM-503 (Opt. (i))</td>
<td>Elasticity</td>
<td>80</td>
<td>20</td>
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<td>MM-503 (Opt. (ii))</td>
<td>Difference Equations-I</td>
<td>80</td>
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<td>MM-503 (Opt. (iii))</td>
<td>Analytic Number Theory</td>
<td>80</td>
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<td>MM-503 (Opt. (iv))</td>
<td>Number Theory</td>
<td>80</td>
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<td>MM-504 (Opt. (i))</td>
<td>Fluid Mechanics – I</td>
<td>80</td>
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<td>MM-504 (Opt. (ii))</td>
<td>Mathematical Statistics</td>
<td>80</td>
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<td>Algebraic Coding Theory</td>
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<tr>
<td>MM-504 (Opt. (iv))</td>
<td>Commutative Algebra</td>
<td>80</td>
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<tr>
<td>MM-505 (Opt. (i))</td>
<td>Integral Equations</td>
<td>80</td>
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<td>Mathematical Modeling</td>
<td>80</td>
<td>20</td>
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<td>Linear Programming</td>
<td>80</td>
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<tr>
<td>MM-505 (Opt. (iv))</td>
<td>Fuzzy Sets &amp; Applications –I</td>
<td>80</td>
<td>20</td>
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<td>MM-506</td>
<td>Practical-III</td>
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## Semester – IV

### Compulsory Papers:

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<th>Paper Code</th>
<th>Nomenclature</th>
<th>External Theory Exam. Marks</th>
<th>Internal Assessment Marks</th>
<th>Max. Marks</th>
<th>Examination Hours</th>
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<tr>
<td>MM-507</td>
<td>General Measure and Integration Theory</td>
<td>80</td>
<td>20</td>
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<tr>
<td>MM-508</td>
<td>Partial Differential Equations</td>
<td>80</td>
<td>20</td>
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### Optional Papers:

A candidate can opt one optional paper from MM-509 opt (i) to opt (iv). Similarly one paper will be opted each from MM-510 opt (i) to opt (iv) and MM-511 opt (i) to opt (iv)

<table>
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<th>Paper Code</th>
<th>Nomenclature</th>
<th>External Theory Exam. Marks</th>
<th>Internal Assessment Marks</th>
<th>Max. Marks</th>
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<tr>
<td>MM-509 (Opt. (i))</td>
<td>Mechanics of Solids</td>
<td>80</td>
<td>20</td>
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<td>Difference Equations-II</td>
<td>80</td>
<td>20</td>
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<td>MM-509 (Opt. (iii))</td>
<td>Algebraic Number Theory</td>
<td>80</td>
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<td>MM-509 (Opt. (iv))</td>
<td>Mathematics for Finance &amp; Insurance</td>
<td>80</td>
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<td>MM-510 (Opt. (i))</td>
<td>Fluid Mechanics-II</td>
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<td>Boundary Value Problems</td>
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<td>MM-510 (Opt. (iii))</td>
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<td>MM-511 (Opt. (i))</td>
<td>Mathematical Aspects of Seismology</td>
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<td>MM-511 (Opt. (ii))</td>
<td>Dynamical Systems</td>
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<td>MM-511</td>
<td>Operational Research</td>
<td>80</td>
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<td>MM-511</td>
<td>Fuzzy Sets &amp; Applications-II</td>
<td>80</td>
<td>20</td>
<td>100</td>
<td>3 Hours</td>
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<td>(Opt. (iv)</td>
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<td>MM-512</td>
<td>Practical-IV</td>
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Semester – I

MM-401: Advanced Abstract Algebra-I

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)

Automorphisms and Inner automorphisms of a group G. The groups Aut(G) and Inn(G). Automorphism group of a cyclic group. Normalizer and Centralizer of a non-empty subset of a group G. Conjugate elements and conjugacy classes. Class equation of a finite group G and its applications. Derived group (or a commutator subgroup) of a group G. Perfect groups. Zassenhau’s Lemma. Normal and Composition series of a group G. Scheier’s refinement theorem. Jordan Holder theorem. Composition series of groups of order $p^n$ and of Abelian groups. Cauchy theorem for finite groups. $\prod$ - groups and $p$-groups. Sylow $\prod$-subgroups and Sylow p-subgroups. Sylow’s Ist, IInd and IIIrd theorems. Application of Sylow theory to groups of smaller orders.

Section – II (Two Questions)


Section – III (Two Questions)

Section – IV (Two Questions)

Solvable groups Derived series of a group $G$. Simplicity of the Alternating group $A_n$ ($n \geq 5$). Non-solvability of the symmetric group $S_n$ and the Alternating group $A_n$ ($n \geq 5$). Roots of unity Cyclotomic polynomials and their irreducibility over $Q$. Radicals extensions. Galois radical extensions. Cyclic extensions. Solvability of polynomials by radicals over $Q$. Symmetric functions and elementary symmetric functions. Construction with ruler and compass only.

Recommended Books:

1. I.D. MacDonald. : The theory of Groups
2. P.B. Bhattacharya

Reference Books:

1. Vivek Sahai and Vikas Bist : Algebra (Narosa publication House)
2. I.S. Luthar and I.B.S. Passi : Algebra Vol. 1 Groups (Narosa publication House)
3. I.N. Herstein : Topics in Algebra (Wiley Eastern Ltd.)
Semester-I

MM-402 : REAL ANALYSIS –I

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)

Definition and existence of Riemann Stieltjes integral, properties of the integral, integration and differentiation, the fundamental theorem of integral calculus, integration by parts, integration of vector-valued functions, Rectifiable curves. (Scope as in Chapter 6 of ‘Principles of Mathematical Analysis’ by Walter Rudin, Third Edition).

Section-II (Two Questions)

Pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weirstrass M-test, Abel’s test and Dirichlet’s test for uniform convergence, uniform convergence and continuity, uniform convergence and Riemann Stieltjes integration, uniform convergence and differentiation, existence of a real continuous nowhere differentiable function, equicontinuous families of functions, Weierstrass approximation theorem (Scope as in Sections 7.1 to 7.27 of Chapter 7 of Principles of Mathematical Analysis by Walter Rudin, Third Edition).

Section-III (Two Questions)

Functions of several variables : linear transformations, Derivative in an open subset of $\mathbb{R}^n$, Chain rule, Partial derivatives, directional derivatives, the contraction principle, inverse function theorem, Implicit function theorem, Jacobians, extremum problems with constraints, Lagrange’s multiplier method, Derivatives of higher order, mean value theorem for real functions of two variables, interchange of the order of differentiation, Differentiation of integrals.

(Scope as in relevant portions of Chapter 9 of ‘Principles of Mathematical Analysis’ by Walter Rudin, Third Edition)
Section-IV (Two Questions)

Power Series: Uniqueness theorem for power series, Abel’s and Tauber’s theorem, Taylor’s theorem, Exponential & Logarithm functions, Trigonometric functions, Fourier series, Gamma function
(Scope as in Chapter 8 of ‘Principles of Mathematical Analysis’ by Walter Rudin, Third Edition).

Integration of differential forms: Partitions of unity, differential forms, stokes theorem
(scope as in relevant portions of Chapter 9 & 10 of ‘Principles of Mathematical Analysis’ by Walter Rudin (3rd Edition).

Recommended Text:

Reference Books:
M.Sc.(P)Mathematics Semester-I
Semester-I

MM-403: TOPOLOGY

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)

Definition and examples of topological spaces, Neighbourhoods, Neighbourhood system of a point and its properties. Interior point and interior of a set, interior as an operator and its properties, definition of a closed set as complement of an open set, limit point (accumulation point) of a set, derived set of a set, definition of closure of a set as union of the set and its derived set, Adherent point (Closure point) of a set, closure of a set as set of adherent (closure) points, properties of closure, closure as an operator and its properties, boundary of a set, Dense sets. A characterization of dense sets. Base for a topology and its characterization, Base for Neighbourhood system, Sub-base for a topology. Relative (induced) Topology and subspace of a topological space. Alternate methods of defining a topology using ‘properties’ of ‘Neighbourhood system’, ‘Interior Operator’, ‘Closed sets’, Kuratowski closure operator and ‘base’. First countable, Second countable and separable spaces, their relationships and hereditary property. About countability of a collection of disjoint open sets in a separable and a second countable space, Lindelof theorem. Comparison of Topologies on a set, about intersection and union of topologies, infimum and supremum of a collection of topologies on a set, the collection of all topologies on a set as a complete lattice (scope as in theorems 1-16, chapter 1 of Kelley’s book given at Sr. No. 1).

SECTION-II (Two Questions)

Definition, examples and characterisations of continuous functions, composition of continuous functions, Open and closed functions, Homeomorphism, embedding. Tychonoff product topology in terms of standard (defining) subbase, projection maps, their continuity and openness, Characterisation of product topology as the smallest topology with projections continuous, continuity of a function from a space into a product of spaces.
T₀, T₁, T₂, Regular and T₃ separation axioms, their characterization and basic properties i.e. hereditary property of T₀, T₁, T₂, Regular and T₃ spaces, and productive property of T₁ and T₂ spaces.

Quotient topology w.r.t. a map, Continuity of function with domain a space having quotient topology, About Hausdorffness of quotient space (scope as in theorems 1, 2, 3, 5, 6, 8-11, Chapter 3 and relevant portion of chapter 4 of Kelley’s book given at Sr.No.1)

**Section-III (Two Questions)**

Completely regular and Tychonoff (T 3½), spaces, their hereditary and productive properties. Embedding lemma, Embedding theorem.

Normal and T₄ spaces : Definition and simple examples, Urysohn’s Lemma, complete regularity of a regular normal space, T₄ implies Tychonoff, Tietze’s extension theorem (Statement only). (Scope as in theorems 1-7, Chapter 4 of Kelley’s book given at Sr. No. 1).

Definition and examples of filters on a set, Collection of all filters on a set as a p.o. set, finer filter, methods of generating filters/finer filters, Ultra filter (u.f.) and its characterizations, Ultra Filter Principle (UFP) i.e. Every filter is contained in an ultra filter. Image of filter under a function.

Convergence of filters: Limit point (Cluster point) and limit of a filter and relationship between them, Continuity in terms of convergence of filters. Hausdorffness and filter convergence.

**Section-IV (Two Questions)**

Compactness: Definition and examples of compact spaces, definition of a compact subset as a compact subspace, relation of open cover of a subset of a topological space in the sub-space with that in the main space, compactness in terms of finite intersection property (f.i.p.), continuity and compact sets, compactness and separation properties, Closedness of compact subset, closeness of continuous map from a compact space into a Hausdorff space and its consequence, Regularity and normality of a compact Hausdorff space.

Compactness and filter convergence, Convergence of filters in a product space, compactness and product space. Tychonoff product theorem using filters, Tychonoff space as a subspace of a compact Hausdorff space and its converse, compactification and Hausdorff compactification, Stone-Cech compactification, (Scope as in theorems 1,7-11, 13, 14, 15, 22-24, Chapter 5 of Kelley’s book given at Sr. No. 1).

**Books :**

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)

Power series, its convergence, radius of convergence, examples, sum and product, differentiability of sum function of power series, property of a differentiable function with derivative zero. expz and its properties, logz, power of a complex number (z^n), their branches with analyticity.
Path in a region, smooth path, p.w. smooth path, contour, simply connected region, multiply connected region, bounded variation, total variation, complex integration, Cauchy-Goursat theorem, Cauchy theorem for simply and multiply connected domains.

Section II (Two Questions)

Index or winding number of a closed curve with simple properties. Cauchy integral formula. Extension of Cauchy integral formula for multiple connected domain. Higher order derivative of Cauchy integral formula. Gauss mean value theorem Morera’s theorem. Cauchy’s inequality. Zeros of an analytic function, entire function, radius of convergence of an entire function, Liouville’s theorem, Fundamental theorem of algebra, Taylor’s theorem.

Section-III (Two Questions)


Section-IV (Two Questions)

Residue : Residue at a singularity, residue at a simple pole, residue at infinity. Cauchy residue theorem and its use to calculate certain integrals, definite integral (∫_0^2π f(cosθ, sinθ) dθ, ∫_∞^-∞ f(x)dx), integral of the type ∫_0^π f(x) sinmx dx or ∫_0^π f(x) cosmx dx, poles on the real axis, integral of many valued functions.
Bilinear transformation, their properties and classification, cross ration, preservance of cross ration under bilinear transformation, preservance of circle and straight line under bilinear transformation, fixed point bilinear transformation, normal form of a bilinear transformation. Definition and examples of conformal mapping, critical points.

Books recommended:

Reference Books:
Semester-I

MM-405: Differential Equations –I

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)

Preliminaries: Initial value problem and equivalent integral equation, $\varepsilon$-approximate solution, equicontinuous set of functions.
(Relevant portions from the book of ‘Theory of Ordinary Differential Equations’ by Coddington and Levinson)

Section-II (Two Questions)

Linear differential systems: Definitions and notations. Linear homogeneous systems; Fundamental matrix, Adjoint systems, reduction to smaller homogeneous systems. Non-homogeneous linear systems; variation of constants. Linear systems with constant coefficients. Linear systems with periodic coefficients; Floquet theory.
(Relevant portions from the book of ‘Theory of Ordinary Differential Equations’ by Coddington and Levinson)

Section-III (Two Questions)

Section –IV (Two Questions)

System of differential equations, the n-th order equation. Dependence of solutions on initial conditions and parameters: Preliminaries, continuity and differentiability. (Relevant portions from the book ‘Theory of Ordinary Differential Equations’ by Coddington and Levinson)


References:
2. S.L. Ross, *Differential Equations*, John Wiley & Sons,
Semester-I

Paper MM-406 : Practical-I

Examination Hours : 4 hours
               Max. Marks : 100

Part-A : Problem Solving

In this part, problem-solving techniques based on papers MM-401 to MM-405 will be taught.

Part-B : Implementation of the following programs in ANSI C.

1. Use of nested if..else in finding the smallest of four numbers.
2. Use series sum to compute \( \sin(x) \) and \( \cos(x) \) for given angle \( x \) in degrees. Then, check error in verifying \( \sin^2x + \cos^2(x) = 1 \).
3. Verify \( \sum n^3 = (\sum n)^2 \), (where \( n=1,2,...,m \)) & check that prefix and postfix increment operator gives the same result.
4. Compute simple interest of a given amount for the annual rate = .12 if amount \( >=10,000/- \) or time \( >=5 \) years; = .15 if amount \( >=10,000/- \) and time \( >=5 \) years; and = .10 otherwise.
5. Use array of pointers for alphabetic sorting of given list of English words.
6. Program for interchange of two rows or two columns of a matrix. Read/write input/output matrix from/to a file.
7. Calculate the eigenvalues and eigenvectors of a given symmetric matrix of order 3.
8. Calculate standard deviation for a set of values \( \{x(j)j=1,2,...,n\} \) having the corresponding frequencies \( \{f(j)j=1,2,...,n\} \).
9. Find GCD of two positive integer values using pointer to a pointer.
10. Compute GCD of 2 positive integer values using recursion.
11. Check a given square matrix for its positive definite form.
12. To find the inverse of a given non-singular square matrix.

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.
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)

Commutators and higher commutators. Commutators identities. Commutator subgroups. Derived group. Three subgroups Lemma of P.Hall. Central series of a group G. Nilpotent groups. Centre of a nilpotent group. Subgroups and factor subgroups of nilpotent groups. Finite nilpotent groups. Upper and lower central series of a group G and their properties. Subgroups of finitely generated nilpotent groups. Sylow-subgroups of nilpotent groups. (Scope of the course as given in the book at Sr. No. 2).

Section-II (Two Questions)


Section-III (Two Questions)

Section-IV (Two Questions)


Recommended Books:

2. Theory of Groups : I.D. Macdonald
3. Topics in Algebra : I.N. Herstein
4. Group Theory : W.R. Scott
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)

Lebesgue outer measure, elementary properties of outer measure, Measurable sets and their properties, Lebesgue measure of sets of real numbers, algebra of measurable sets, Borel sets and their measurability, characterization of measurable sets in terms of open, closed, F and G sets, existence of a non-measurable set.

Lebesgue measurable functions and their properties, characteristic functions, simple functions, approximation of measurable functions by sequences of simple functions, measurable functions as nearly continuous functions. Borel measurability of a function.

Section-II (Two Questions)

Almost uniform convergence, Egoroff’s theorem, Lusin’s theorem, convergence in measure, F.Riesz theorem that every sequence which is convergent in measure has an almost everywhere convergent subsequence.

The Lebesgue Integral:

Shortcomings of Riemann integral, Lebesgue integral of a bounded function over a set of finite measure and its properties, Lebesgue integral as a generalization of the Riemann integral, Bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions.

Section-III (Two Questions)

Integral of a non negative function, Fatou’s lemma, Monotone convergence theorem, integration of series, the general Lebesgue integral, Lebesgue convergence theorem.

Differentiation and Integration:

Differentiation of monotone functions, Vitali’s covering lemma, the four Dini derivatives, Lebesgue differentiation theorem, functions of bounded variation and their representation as difference of monotone functions.
Section-IV (Two Questions)

Differentiation of an integral, absolutely continuous functions, convex functions, Jensen’s inequality.

The L_p spaces

The L_p spaces, Minkowski and Holder inequalities, completeness of L_p spaces, Bounded linear functionals on the L_p spaces, Riesz representation theorem.

Recommended Text:


Reference Books:

Semester-II

MM-409 : Computer Programming (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)
Numerical constants and variables; arithmetic expressions; input/output; conditional flow; looping.

Section-II (Two Questions)
Logical expressions and control flow; functions; subroutines; arrays.

Section-III (Two Questions)
Format specifications; strings; array arguments, derived data types.

Section-IV (Two Questions)
Processing files; pointers; modules; FORTRAN 90 features; FORTRAN 95 features.

Recommended Text:

References:
MM-410 : COMPLEX ANALYSIS-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)
Spaces of analytic functions and their completeness, Hurwitz’s theorem, Montel’s
theorem, Riemann mapping theorem, infinite products, Weierstrass factorization theorem,
Factorization of sine function, Gamma function and its properties, functional equation for
gamma function, Integral version of gamma function.

Section-II (Two Questions)
Riemann-zeta function, Riemann’s functional equation, 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.

Section-III (Two Questions)
Monodromy theorem and its consequences. Harmonic function as a disk, Poisson’s
Kernel. Harnack’s inequality, Harnack’s theorem, Canonical product, Jensen’s formula,
Poisson-Jensen formula, Hadamard’s three circle theorem. Dirichlet problem for a unit
disk. Dirichlet problem for a region, Green’s function.

Section-IV (Two Questions)
Order of an entire function, Exponent of convergence, Borel theorem, Hadamard’s
factorization theorem. The range of an analytic function, Bloch’s theorem, Little-Picard
theorem, Schottky’s theorem, Montel-Caratheory theorem, Great Picard theorem.
Univalent functions, Bieberbach’s conjecture (Statement only), and $1^7/4$ theorem.
**Books recommended :**


**Reference Books :**

Semester-II

MM-411: DIFFERENTIAL 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)


Section –II (Two Questions)

Sturm theory: Sturm separation theorem, Sturm fundamental comparison theorem and its corollaries. Elementary linear oscillations.
Autonomous systems: the phase plane, paths and critical points, Types of critical points; Node, Center, Saddle point, Spiral point. Stability of critical points. Critical points and paths of linear systems: basic theorems and their applications.

Section-III (Two Questions)

Critical points and paths of non-linear systems: basic theorems and their applications.
Liapunov function. Liapunov’s direct method for stability of critical points of non-linear systems.
Section-IV (Two Questions)


(Relevant portions from the book ‘Textbook of Ordinary Differential Equations’ by Deo et al.)

References:

2. S.L. Ross, *Differential Equations*, John Wiley & Sons,
Semester-II

Paper MM-412 : Practical-II

Examination Hours : 4 hours
Max. Marks : 100

Part-A : Problem Solving

In this part, problem solving techniques based on papers MM-407 to MM-411 will be taught.

Part-B : Implementation of the following programs in FORTRAN-90

1. Calculate the area of a triangle with given lengths of its sides.
2. Given the centre and a point on the boundary of a circle, find its perimeter and area.
3. To check an equation $ax^2 + by^2 + 2cx + 2dy + e = 0$ in $(x, y)$ plane with given coefficients for representing parabola/hyperbola/ellipse/circle or else.
4. For two given values $x$ and $y$, verify $g^2 = a^2 + h^2$, where $a$, $g$ and $h$ denote the arithmetic, geometric and harmonic means respectively.
5. Use IF..THEN..ELSE to find the largest among three given real values.
6. To solve a quadratic equation with given coefficients, without using COMPLEX data type.
7. To find the location of a given point $(x, y)$ i) at origin, ii) on $x$-axis or $y$-axis iii) in quadrant I, II, III or IV.
8. To find if a given 4-digit year is a leap year or not.
9. To find the greatest common divisor (gcd) of two given positive integers.
10. To verify that sum of cubes of first $m$ positive integers is same as the square of the sum of these integers.
11. Find error in verifying $\sin(x+y) = \sin(x) \cos(y) + \cos(x) \sin(y)$, by approximating the $\sin(x)$ and $\cos(x)$ functions from the finite number of terms in their series expansions.
12. Use SELECT...CASE to calculate the income tax on a given income at the existing rates.

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.
SEMESTER-III

MM-501  Functional Analysis

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)
Normed linear spaces, Banach spaces and examples, subspace of a Banach space, completion of a normed space, quotient space of a normed linear space and its completeness, product of normed 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, definite integral, canonical mapping, linear operators and functionals on finite dimensional spaces, normed spaces of operators, dual spaces with examples. (Scope of this section is as in relevant parts of Chapter 2 of ‘Introductory Functional Analysis with Applications’ by E.Kreyszig)

SECTION-II (Two Questions)
Hahn-Banach theorem for real linear spaces, complex linear spaces and 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. (Scope of this section is as in relevant parts of sections 4.1 to 4.7 of Chapter 4 of ‘Introductory Functional Analysis with Applications’ by E.Kreyszig)

SECTION-III (Two Questions)
Strong and weak convergence, weak convergence in $l^p$, convergence of sequences of operators, uniform operator convergence, strong operator convergence, weak operator convergence, strong and weak* convergence of a sequence of functionals. Open mapping theorem, bounded inverse theorem, closed linear operators, closed graph theorem, differential operator, relation between closedness and boundedness of a linear operator. (Scope of this section is as in relevant parts of sections 4.8, 4.9, 4.12 and 4.13 of Chapter 4 of ‘Introductory Functional Analysis with Applications’ by E.Kreyszig)
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. (Scope as in relevant parts of sections 3.1, 3.2 and 3.3 of Chapter 3 of ‘Introductory Functional Analysis with Applications’ by E.Kreyszig)

SECTION-IV (Two Questions)
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. (Scope of this section is as in relevant parts of sections 3.4 to 3.6 and 3.8 to 3.10 of Chapter 3 and sections 9.3 to 9.6 of Chapter 9 of ‘Introductory Functional Analysis with Applications’ by E.Kreyszig.

**Recommended Text:**

**References:**
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)
Motivating problems of calculus of variations: shortest distance, Minimum surface of revolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Fundamental Lemma of calculus of variation. Euler’s equation for one dependent function of one and several independent variables, and its generalization to (i) Functional depending on ‘n’ dependent functions, (ii) Functional depending on higher order derivatives. Variational derivative, invariance of Euler’s equations, natural boundary conditions and transition conditions, Conditional extremum under geometric constraints and under integral constraints. Variable end points.

SECTION-II (Two Questions)

SECTION-III (Two Questions)

SECTION-IV (Two Questions)

Books:


4. Francis B. Hilderbrand, Methods of applied mathematics, Prentice Hall.


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)
Tensor Algebra: Coordinate-transformation, Cartesian Tensor of different order. Properties of tensors, Isotropic tensors of different orders and relation between them, Symmetric and skew symmetric tensors. Tensor invariants, Deviatoric tensors, Eigen-values and eigen-vectors of a tensor.
Tensor Analysis: Scalar, vector, tensor functions, Comma notation, Gradient, divergence and curl of a vector / tensor field. (Relevant portions of Chapters 2 and 3 of book by D.S. Chandrasekharaiiah and L Debnath)

SECTION-II (Two Questions)
Analysis of Strain: Affine transformation, Infinitesimal affine deformation, Geometrical Interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariance, General infinitesimal deformation. Saint-Venant's equations of compatibility. Finite deformations
Analysis of Stress: Stress Vecotr, Stress tensor, Equations of equilibrium, Transformation of coordinates.
(Relevant portion of Chapter I & II of book by I.S. Sokolnikoff).

SECTION-III (Two Questions)
(Relevant portion of Chapter II & III of book by I.S. Sokolnikoff).
SECTION-IV (Two Questions)

(Rellevant portion of Chapter III of book by I.S.Sokolnikoff).

Books:

SEMESTER-III
MM-503 (opt. ii) Difference Equations-I

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)
Introduction, the difference calculus: The difference operator, falling factorial power \( r^t \), binomial coefficient \( \binom{t}{r} \), summation, definition, properties and examples, Abel’s summation formula, Generating functions, Euler’s summation formula, Bernoulli polynomials and examples, approximate summation.

SECTION-II (Two Questions)
Linear Difference Equation: First order linear equations, general results for linear equations, solution of linear difference equation with constant coefficients and with variable coefficients, Non-Linear Equations that can be linearized, applications.

SECTION-III (Two Questions)

SECTION-IV (Two Questions)
The Z-Transform, definition, Properties, initial and final value Theorem, Convolution Theorem, Solving the initial value problems, Volterra summation equation and Fredholm summation equation by use of Z-Transform.
**Recommended Text:**

**Reference Book:**
SEMESTER-III  
MM-503 (opt.iii) Analytic 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)  
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.

SECTION-II (Two Questions)  
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 \( P_n \).

SECTION-III (Two Questions)  
_Sharper’s Tauberian theorem. Applications of Sharper’s theorem. An asymptotic formula for the partial sums \( \sum_{p \leq x} \frac{1}{p} \). Partial sums of the Mobius function. Brief sketch of an elementary proof of the prime number theorem; Selberg’s asymptotic formula.

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 \( \chi \).

SECTION-IV (Two Questions)  

**Recommended Book:**

Tom M. Apostol  
Introduction to Analytic Number Theory
SEMESTER-III
MM-503 (opt. iv) 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)
The equation ax+by = c, simultaneous linear equations, Pythagorean triangles, assorted examples, ternary quadratic forms, rational points on curves.

SECTION-II (Two Questions)
Elliptic curves, Factorization using elliptic curves, curves of genus greater than 1. Farey sequences, rational approximations, Hurwitz theorem, irrational numbers, Geometry of Numbers, Blichfeldt’s principle, Minkowski’s Convex body theorem Lagrange’s four square theorem.

SECTION-III (Two Questions)
Euclidean algorithm, infinite continued fractions, irrational numbers, approximations to irrational numbers, Best possible approximations, Periodic continued fractions, Pell’s equation.

SECTION-IV (Two Questions)
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.

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

SECTION-II (Two Questions)

SECTION –III (Two Questions)

SECTION –IV (Two Questions)
Reduction of Navier-Stoke equations in flows having axis of symmetry, steady flow in circular pipe: the Hagen-Poiseuille flow, steady flow between two coaxial cylinders, flow between two concentric rotating cylinders. Steady flows through tubes of uniform cross-section in the form (i) Ellipse, (ii) equilateral triangle, (iii) rectangle, under constant pressure gradient, uniqueness theorem.
Books:

Semester-III

MM : 504 (opt. ii) Mathematical Statistics

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)
Random distribution: preliminaries, Probability density function, Probability models, Mathematical Expectation, Chebyshev’s Inequality; Conditional probability, Marginal and conditional distributions, Correlation coefficient, Stochastic independence.

Section-II (Two Questions)
Frequency distributions: Binomial, Poisson, Gamma, Chi-square, Normal, Bivariate normal distributions.
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.

Section-III (Two Questions)
Limiting distributions: Stochastic convergence, Moment generating function, Related theorems.
Intervals: Random intervals, Confidence intervals for mean, differences of means and variance; Bayesian estimation.

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

Books:
Semester – III
MM-504 (opt. iii) Algebraic Coding 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)

SECTION – II (Two Questions)
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-Hocquenghem codes (BCH codes) construction of BCH codes over finite fields. (Chapter 4 of the book given at Sr. No. 1 and Section 7.1 to 7.3 of the book given at Sr. No. 2).

SECTION – III (Two Questions)
SECTION – IV (Two Questions)

Recommended Text :
1. L.R. Vermani : Elements of Algebraic Coding Theory (Chapman and Hall Mathematics)
2. Steven Roman : Coding and Information Theory (Springer Verlag)
SEMMEREST-III
MM-504 (opt. iv) Commutative Algebra

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)

SECTION-II  (Two Questions)

SECTION-III  (Two Questions)
Integral elements, Integral closure and integrally closed domains, Going-up theorem and the Going-down theorem, valuation rings and local rings, Noether’s normalization lemma and weak form of nullstellensatz Chain condition, Noetherian and Artinian modules, composition series and chain conditions.

SECTION-IV  (Two Questions)
Noetherian rings and primary decomposition in Noetherian rings, radical of an ideal. Nil radical of an Artinian ring, Structure Theorem for Artinian rings, Discrete valuation rings, Dedekind domains, Fractional ideals.

(Scope of the course is as given in Chapter 1 to 9 of the recommended text).
**Recommended Text:**
M.F. Atiyah, FRS and I.G. Macdonald
Introduction to Commutative Algebra
(Addison-Wesley Publishing Company)

**Reference Books:**
1. N.S. Gopal Krishnan, Oxonian Press Pvt. Ltd. Commutative Algebra
SEMESTER-III
MM-505 (opt. i) Integral Equations

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)
(Relevant portions from the Chapters 1 & 2 of the book “Linear Integral Equations, Theory & Techniques by R.P.Kanwal”).

SECTION-II (Two Questions)
Classical Fredholm’s theory, the method of solution of Fredholm equation, Fredholm’s First theorem, Fredholm’s second theorem, Fredholm’s third theorem.
(Relevant portions from the Chapter 3 & 4 of the book “Linear Integral Equation, Theory and Techniques by R.P.Kanwal”).

SECTION-III (Two Questions)
Symmetric Kernels, Introduction, Complex Hilbert space. An orthonormal system of functions, Riesz-Fisher theorem, A complete two-Dimensional orthonormal set over the rectangle $a \leq s \leq b, c \leq t \leq d$. Fundamental properties of Eigenvalues and Eigenfunctions for symmetric Kernels. Expansion in eigen functions and Bilinear form. Hilbert-Schmidt theorem and some immediate consequences.
(Relevant portions from the Chapter 7 of the book “Linear Integral Equation, Theory and Techniques by R.P.Kanwal”).

SECTION-IV (Two Questions)
The Abel Integral 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 Integral equation.
(Relevant portions from the Chapter 8 of the book “Linear Integral Equation, Theory and Techniques by R.P.Kanwal”).
References:
5. Pundir and Pundir, Integral Equations and Boundary value problems, Pragati Prakashan, Meerut.
Semester-III

MM 505 : (opt. ii) Mathematical Modeling

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 process of Applied Mathematics; mathematical modeling: need, techniques, classification and illustrative; mathematical modeling through ordinary differential equation of first order; qualitative solutions through sketching.

Section-II (Two Questions)

Mathematical modeling in population dynamics, epidemic spreading and compartment models; mathematical modeling through systems of ordinary differential equations; mathematical modeling in economics, medicine, arm-race, battle.

Section-III (Two Questions)

Mathematical modeling through ordinary differential equations of second order. Higher order (linear) models. Mathematical modeling through difference equations: Need, basic theory; mathematical modeling in probability theory, economics, finance, population dynamics and genetics.

Section-IV (Two Questions)

Mathematical modeling through partial differential equations: simple models, mass-balance equations, variational principles, probability generating function, traffic flow problems, initial & boundary conditions.

Book recommended :

J.N. Kapur: Mathematical Modeling, Wiley Eastern Limited, 1990 (Relevant portions, mainly from Chapters 1 to 6.)
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)
Simultaneous linear equations, Basic solutions, Linear transformations, Point sets, Lines and hyperplanes, Convex sets, Convex sets and hyperplanes, Convex cones, Restatement of the Linear Programming problem, Slack and surplus variables, Preliminary remarks on the theory of the simplex method, Reduction of any feasible solution to a basic feasible solution, Definitions and notations regarding linear programming problems. Improving a basic feasible solution, Unbounded solutions, Optimality conditions, Alternative optima, Extreme points and basic feasible solutions.

Section-II (Two Questions)
The simplex method, Selection of the vector to enter the basis, Degeneracy and breaking ties, Further development of the transformation formulas, The initial basic feasible solution———artificial variables, Inconsistency and redundancy, Tableau format for simplex computations, Use of the tableau format, Conversion of a minimization problem to a maximization problem, Review of the simplex method.
The two-phase method for artificial variables, Phase I, Phase II, Numerical examples of the two-phase method, Requirements space, Solutions space, Determination of all optimal solutions, Unrestricted variables, Charnes’ perturbation method regarding the resolution of the degeneracy problem.

Section-III (Two Questions)
Selection of the vector to be removed, Definition of b(€). Order of vectors in b(€), Use of perturbation technique with simplex tableau format, Geometrical interpretation of the perturbation method. The generalized linear programming problem, The generalized simplex method, Examples pertaining to degeneracy, An example of cycling.
Revised simplex method: Standard Form I, Computational procedure for Standard Form I, Revised simplex method: Standard Form II, Computational procedure for Standard Form II, Initial identity matrix for Phase I, Comparison of the simplex and revised simplex methods, The product form of the inverse of a non-singular matrix. Alternative formulations of linear programming problems,

Section-IV (Two Questions)
Dual linear programming problems, Fundamental properties of dual problems, Other formulations of dual problems, Complementary slackness, Unbounded solution in the primal, Dual simplex algorithm, Alternative derivation of the dual simplex algorithm, Initial solution for dual simplex algorithm, The dual simplex algorithm; an example, geometric interpretations of the dual linear programming problem and the dual simplex algorithm. A primal dual algorithm, Examples of the primal-dual algorithm.
Transportation problem, its formulation and simple examples.
Books:
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)
Fuzzy Sets: Basic definitions, \( \alpha \)-cuts, strong \( \alpha \)-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 (Scope as in relevant parts of sections 1.3-1.4 of Chapter 1 of the book given at Sr.No.1).

Additional properties of \( \alpha \)-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 (Scope as in relevant parts of Chapter 2 of the book mentioned at the end).

SECTION-II (Two Questions)
Operators 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, conversion 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) (Scope as in relevant parts of sections 3.1 to 3.4 of Chapter 3 of the book mentioned at the end).
SECTION-III (Two Questions)
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 operators 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 (Scope as in relevant parts of sections Chapter 4 of book mentioned at the end).

SECTION-IV (Two Questions)
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, $\alpha$-compatibility class, maximal $\alpha$-compatibles, complete $\alpha$-cover, reflexive undirected graphs, fuzzy ordering relations, fuzzy upper bound, fuzzy pre ordering, fuzzy weak ordering, fuzzy strict ordering, fuzzy morphisms.
(Scope of this section is as in the relevant parts of sections 5.1 to 5.8 of Chapter 5 of the book mentioned at the end).

Recommended Text:
Semester-III

Paper MM- 506 : Practical-III

Examination Hours : 4

hours

Max. Marks : 100

Part-A : Problem Solving

In this part, problem solving techniques based on papers MM-501 to MM-505 will be taught.

Part-B : Implementation of the following programs in FORTRAN-90/95

1. Use a function program for simple interest to display year-wise compound interest and amount, for given deposit, rate and time.
2. Use logical operators in computing the compound interest on a given amount for rate of interest varying with amount as well as time of deposit.
3. Write a subroutine program to check (logical output) whether the three given points in a plane are collinear.
4. Use subroutine program to multiply two given matrices and use resource files in main program to read input and write output.
5. Use ALLOCATABLE size declaration for given set of points in a plane and fit a straight line through these points.
6. Write a program to display the use of whole-array operations on non-conformable arrays.
7. Write a program to display the procedure of format-rescan-rule and the action of tab-edit descriptors.
8. Use string operations to find if a given string is a palindrome or not.
9. Compute a given definite integral (as summation) in a subroutine using integrand as a dummy argument.
10. Explain the use of MODULE in defining an abstract (derived) data type for complex arithmetic.
11. Use of pointers in manipulating a linked-list.
12. To solve a quadratic equation with given (complex-valued) coefficients, using COMPLEX data type

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.
SEMESTER-IV
MM-507  General Measure and Integration 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)
Measures, some properties of measures, outer measures, extension of measures, uniqueness of extension, completion of a measure, the LUB of an increasingly directed family of measures.(Scope as in the Sections 3-6, 9-10 of Chapter 1 of the book ‘Measure and Integration’ by S.K.Berberian).
Measurable functions, combinations of measurable functions, limits of measurable functions, localization of measurability, simple functions (Scope as in Chapter 2 of the book ‘Measure and Integration’ by S.K.Berberian).

SECTION-II (Two Questions)
Measure spaces, almost everywhere convergence, fundamental almost everywhere, convergence in measure, fundamental in measure, almost uniform convergence, Egoroff’s theorem, Riesz-Weyl theorem (Scope as in Chapter 3 of the book ‘Measure and Integration’ by S.K.Berberian).
Integration with respect to a measure: Integrable simple functions, non-negative integrable functions, integrable functions, indefinite integrals, the monotone convergence theorem, mean convergence (Scope as in Chapter 4 of the book ‘Measure and Integration’ by S.K.Berberian).

SECTION-III (Two Questions)
Product Measures: Rectangles, Cartesian product of two measurable spaces, measurable rectangle, sections, the product of two finite measure spaces, the product of any two measure spaces, product of two σ - finite measure spaces; iterated integrals, Fubini’s theorem, a partial converse to the Fubini’s theorem (Scope as in Chapter 6 (except section 42) of the book ‘Measure and Integration’ by S.K.Berberian)
Signed Measures: Absolute continuity, finite signed measure, contractions of a finite signed measure, purely positive and purely negative sets, comparison of finite measures, Lebesgue decomposition theorem, a preliminary Radon-Nikodym theorem, Hahn decomposition, Jordan decomposition, upper variation, lower variation, total variation, domination of finite signed measures, the Radyon-Nikodym theorem for a finite measure space, the Radon-Nikodym theorem for a σ - finite measure space (Scope as in Chapter 7 (except Section 53) of the book ‘Measure and Integration’ by S.K.Berberian).
SECTION-IV (Two Questions)
Integration over locally compact spaces: continuous functions with compact support, $G_\delta$’s and $F_\sigma$’s, Baire sets, Baire function, Baire-sandwich theorem, Baire measure, Borel sets, Regularity of Baire measures, Regular Borel measures, Integration of continuous functions with compact support, Riesz-Markoff’s theorem (Scope as in relevant parts of the sections 54-57, 60, 62, 66 and 69 of Chapter 8 of the book ‘Measure and Integration’ by S.K.Berberian)

Recommended Text:

References:
SEMESTER- IV
MM-508 Partial Differential Equations

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)
PDE of kth 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 Formulas, Poisson’s
equation and its solution, strong maximum principle, uniqueness, local estimates for harmonic
functions, Liouville’s theorem, Harnack’s inequality.

SECTION-II (Two Questions)
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 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.

SECTION-III (Two Questions)
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 formulas (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) quasilinera, (iii) fully non-linear first order partial differential
equations. Hamilton Jacobi equations (calculus of variations Hamilton’s ODE, Legendre

SECTION-IV (Two Questions)
Conservative Laws (Shocks, entropy condition, Lax-Oleinik formula., weak solutions uniqueness.
Riemann’s problem, long time behaviour).
Representation of Solutions- Separation of variables, Similarity solutions (Plane and traveling
waves, solitones, similarity under Scaling). Fourier Transform, Laplace Transform, Converting
non linear into linear PDE, Cole-Hop Transform, Potential functions, Hodograph and Legendre
transforms.

Books:
1L.C. Evans, Partial Differential Equations, Graduate Studies in
2 Books with the above title by I.N. Snedden, F. John, P. Prasad and R. Ravindran, Amarnath etc.
SEMESTER-IV
MM-509 (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)

SECTION -II (Two Questions)
(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)
(Chapter 7: Sections 107-110, 112, 113, 115 & 117 of I.S. Sokolnikoff).
**Books:**

SEMESTER-IV

MM-509 (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.

SECTION-III (Two Questions)

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.

Recommend Text:

Reference Book:
SEMESTER-IV

MM-509 (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)

SECTION-II (Two Questions)

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)

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

Semester-IV

MM-509 Option (iv): Mathematics for Finance & Insurance

Examination Hours : 3 Hours
Max. Marks : 100
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)**
Normal Random Variables: Continuous Random Variables, Normal Random Variables & their properties, Central Limit Theorem.
Geometric Brownian Motion: Basic concepts & simple Models, Brownian Motion, Interest Rates, Present Value Analysis, Rate of Return, continuously varying Interest Rates.

**Section – II (Two Questions)**
Financial Derivatives – An Introduction, Types of Financial Derivatives, Forwards and Futures, Options and its kinds and SWAPS
The Arbitrage Theorem and Introduction to Portfolio Selection and Capital Market Theory: Static and Continuous-Time Model.

**Section – III (Two Questions)**
Pricing by Arbitrage-A Single-Period option Pricing Model; Multi-Period Pricing Model, Cox-Ross-Rubinstein Model; Bounds on Option Prices.
The Ito’s Lemma and the Ito’s Integral. Concepts from Insurance: Introduction; The Claim Number Process; The Claim Size Process; Solvability of the Portfolio; Reinsurance and Ruin Problem.

**Section – IV (Two Questions)**
Premium and Ordering of Risks-Premium Calculation Principles and Ordering Distributions.
Distribution of Aggregate Claim Amount-Individual and Collective Model; Compound Distributions; Claim Number of Distributions; Recursive Computation Methods; Lundberg Bounds and Approximation by Compound Distributions.
References:

1. John C.Hull, Options, Futures, and Other Derivatives, Prentice-Hall of India Private Limited.
5. Robert C. Marton, Continuous-Time Finance, Basil Blackwell Inc.
SEMESTER- IV

MM-510 (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.

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)

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:

SEMESTER-IV

MM-510 (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)
(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 problems 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)
( 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, Longitudinal oscillations of solids in stokes Flow, Steady Rotary Stokes
( Relevant portions from the Chapter 11 of the book “Linear Integral Equation, Theory and Techniques by R.P.Kanwal”).

References:

5. Pundir and Pundir, Integral equations and Boundary value problems, Pragati Prakashan, Meerut.
SEMESTER-IV
MM-510 (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. Splitting 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)

SECTION-III (Two Questions)

SECTION-IV (Two Questions)
**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  
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)

SECTION-II (Two Questions)

SECTION-III (Two Questions)

SECTION-IV (Two Questions)
**Recommended Texts:**

1. Narsingh Deo  
   Graph Theory with application to Engineering and Computer Science, Prentice Hall of India.

2. Nathan Jacobson  

3. L.R. Vermani and Shalini College  
   A course in discrete Mathematical structures(Imperial Press London 2011)
SEMESTER-IV

MM-511 (opt. i) Mathematical Aspects of Seismology

Examination Hours : 3

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)


(Relevant articles from the book “Waves” by Coulson & Jefferey)

SECTION-II (Two Questions)


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: Sommerfeld’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:

SEMESTER-IV

MM-511 (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 :


Semester-IV

MM-511 (opt. iii) Operational Research

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 Question)
Dynamic Programming – Nature of Dynamic Programming (DP), Bellman’s principle of optimality in DP, DP algorithm, mathematical formulation of multistage model, the recursive operation approach, Application of DP in Linear Programming.
Integer Programming : types of integer programming problem, cutting plane method (Gomory technique), construction of Gomory’s constraints, Graphical interpretation of cutting plane method, cutting plane algorithm, Fractional cut method, the branch and bound method.

Section – II (Two Question)
Game theory : Definition, characteristics of games, two person, zero sum game, pay of matrix strategy & its types, Saddle point, solution of rectangular game with saddle point, solution method of rectangular game in terms & strategy, strategy of mixed optimal strategy, concept of Dominance, Graphical method of solving (2xn) and (mx2) games, Algebraic method for the solution of general game, equivalence of the rectangular matrix games and linear programming, fundamental theory of game theory, limitation of game theory, solution of rectangular game by singular method, matrix method for (nxn) games.

Section – III (Two questions)
Nonlinear Programming-Definition and examples of non-linear programming, Mobi-Tucker theory: Kuhn-Tucker (K-T) optimality conditions, K-T first order necessary optimality conditions, K-T, second order optimality conditions, Lagrange’s method, Economic interpretation of multipliers-Wolf duality theorem on non-linear programming, Quadratic programming, K-T conditions for Quadratic programming problems, Wolf modified simplex method, Beale’s method, separable, convex and non-convex programming.
Section –IV (Two questions)
Inventory model: classification of inventory models, Deterministic inventory model (DIM), Basic Economic-order quantity (EOQ) models, EOQ model with uniform rate of demand infinite production rate and having no shortage EOQ model with uniform rate of demand in different production cycles, infinite production rate & having non shortage, EOQ with finite replenishment DIM with shortage, Fixed Time Model, EOQ with finite production, EOQ with price break, EOQ with one price break, single multi-item deterministic inventory model, Queuing models: classification of queuing models, solution of queue models, model I (M/M/1) : (∞/FCFS) model II (General Erlong queuing model, model III M/M/1): (N/FCFS). Network (PERT/CPM), schedule chart (Gantt Bar Chart), difference between CPM and PERT, Network components, construction of the Network diagram, CPM analysis.

Books :
1. G.Hadley : Linear Programming
2. C.W. Churchman et.al. : Introduction to Operations Research
3. B.S. Goel & S.K. Mittal : Operations research
4. D. Gross & C.M. Harris : Fundamentals of Queuing Theory
5. A.O. Allen : Probability Statistics & Queuing Theory with
   Computer
   Science Applications
SEMESTER-IV
MM-511 (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 engine, 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, conversion 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:
Semester-IV

Paper MM-512 : 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.